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RECENT ARTILLERY TRIALS AT THE GRUSON WORKS.

NEARLY all the nations of the world which maintain armies were invited to the great shooting trials which took place at the Gruson Works during the week beginning September 22 of this year, and the universal acceptance of these invitations seems to prove that the programme of operations offered a great deal of interest for engineers and artillery men. It was, therefore, a truly international gathering which was welcomed on Monday, September 22, to the new offices of the Gruson Works, at the head of which is Geheimrath Gruson. About two hundred guests were present; military authorities from all countries, for, of course, each state sent its most able officers to this interesting congress. Fig. 1 shows a few characteristic types found among the guests.

Operations were begun by the inspection of the Gruson Works, opportunity thus being offered to see the casting of a plate of hard cast armor plate weighing 80,000 pounds. After this the guests were taken in carriages to the shooting ground of the Gruson Works, near Buckau, where a number of armored gun carriages and armored turrets were inspected. We will have more to say about these latter, for the last day of the trials was devoted to armored objects.

On the second day the guests were taken by a special train to the shooting ground belonging to the works at Tangerhutte. The day was occupied by ex-

FIG. 1.—TYPES ON THE SHOOTING GROUND.

FIG. 2.—QUICK-FIRING CANNON IN MOUNTAIN CARRIAGE.

FIG. 4.—TELEPHONE CONNECTION WITH STAND FOR SPECTATORS. ANNOUNCEMENT OF THE RESULTS OF THE FIRING.

FIG. 3.—12 CM QUICK-FIRING HOWITZER.

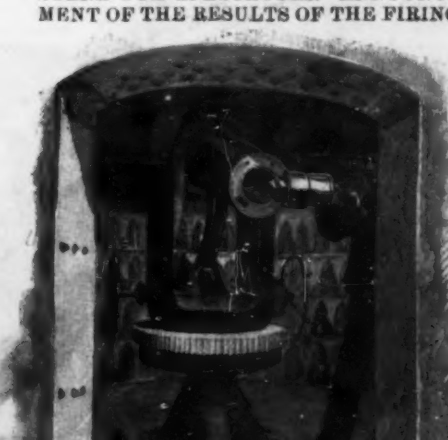


FIG. 8.—THE INTERIOR OF AN ARMORED CARRIAGE FOR A 12 CM. CANNON.

FIG. 5.—QUICK FIRING WITH A 5·3 CM. IN A SHIP'S CARRIAGE, WITH TORPEDO BOAT AS TARGET.

FIG. 6.—TORPEDO BOAT AFTER THE FIRING.

FIG. 7.—PORTABLE ARMORED CARRIAGE FOR A 5·3 CM. QUICK-FIRING CANNON.

FIG. 9.—ADJUSTABLE ARMORED CARRIAGE FOR A 5·3 CM. QUICK-FIRING CANNON.

periments with eight quick firing field guns. Here, as everywhere, the greatest interest was excited by extremes; that is, the smallest and the largest of the guns undergoing trial. The former was a little mountain gun which was brought forward packed on two horses, and in a few minutes was made ready for firing, and immediately aimed at a target more than 3,000 feet away. Fig. 2 represents this cannon, which was manipulated by two men, and at the same time shows the simple but suitable uniform of the artillery men at the Gruson Works. In Fig. 3 we see the largest of the field guns presented, viz., a 12 cm. quick firing howitzer, which was found interesting on account of its peculiar mounting, its trunnions being at the rear end of the tube, instead of in the center, as is usually the case.

This cannon was fired at field works more than 9,000 feet distant, with good results. The special feature of the tests at the Gruson Works was that ordinary targets were not used, but their place was taken by such objects as would be found on the field; for instance, field works, batteries, suddenly raised defenses, etc. The experiments were tests, not only of the artillery materials, but also of the men of the works, and were, therefore, all the more surprising to the spectators. According to the programme, the result of each action was communicated to the battery by the telephone, and the commander of the firing gave his orders in the same manner. Fig. 4 shows the battery telephone in working order.

The next day was spent in testing five long, rapid firing guns in carriages for ships' decks. These cannon are to be used principally for defense against torpedo boats, and are, therefore, preferably fired with hard steel shells. The target for this experiment was the forward part of a torpedo boat made of steel plate. Fig. 5 shows the 5·3 cm. quick firing cannon which was chosen for this test, and which sent thirteen shots through different parts of the torpedo boat in half a minute, so that it would, certainly, have disappeared from view if it had not stood on *terra firma*. Fig. 6 shows the "wreck" during inspection.

The smallest gun tried on this day was a 3·7 cm. rapid firing cannon in a ship's carriage. The beauty of this little gun would give the impression that it was only for ornament, but it proved itself a dangerous weapon when aimed at a target more than 3,000 ft. away.

The largest ship's cannon was a 35 caliber long, 8·2 cm. rapid firing gun, for which a target was placed at a distance of about 8,000 ft. On the next, the fourth day of the trials, four so-called casemate guns, of 4·7 to 7·5 caliber, for the protection of fortresses, were tested. They were directed against ditches the walls of which had been marked by plates so as to test the working of the cartouches, and toward targets arranged to simulate infantry columns, for which they were loaded with sharp shell. The targets were placed at a distance of about 4,000 ft.

At the close of the day guns of that class which has caused so much discussion since the maneuvers of last year, viz., rapid firing cannon with portable armored carriage, were brought forward. Fig. 7 shows such a one being transported. A gun of this kind can be used without even unharnessing the horses, if necessary, or it can be sunken into the ground, or put in any place made ready for it, so that only the revoluble roof is left visible. The gunner is inside, and is thus protected from any flying shots while he is taking aim. There were three different kinds of these armored carriages.

Taking into consideration that the Gruson cannon can easily fire 40 or 50 shots in a minute, the rapid firing gun with the portable armored carriage is a terrible weapon.

The last day, like the first one, was devoted to the inspection of armored objects, many of which were very interesting. That which attracted most attention was the sunken armored carriage which rises suddenly out of the ground as if by magic, fires, and then disappears again before the enemy is ready to take aim at it. We saw armored carriages of this kind provided with heavy 12 cm. cannon as well as with the light quick firing guns. Fig. 8 shows the interior of an armored carriage for a 12 cm. gun, and from it we see that it is not as uncomfortable a habitation as one might suppose.

Fig. 9 represents an armored carriage for a quick firing gun just at the time when it has risen from the ground to open its destructive fire upon the approaching enemy.

In Fig. 10 we see a so-called ball mortar, which is not a mortar in which round shot is used in the good old fashioned way, but one which has a tube provided with a ball-shaped armor that completely closes a round cavity formed in a horizontal plate. At the first glance, such a mortar certainly has a strong resemblance to a turtle, but its comical appearance is forgotten when the excellence of its operation is understood.

Our last illustration, Fig. 11, shows the largest of the armored objects visited on that day, that is, an armored turret for two 15 cm. cannons, such as has been much talked of lately, because the recoil of the cannon is here entirely overcome. The ease with which this great structure turns is astonishing, requiring only 41 seconds to make a complete revolution. Unfortunately, we have not sufficient space to permit of mentioning all of the objects inspected on that day, but we will refer to the 21 cm. howitzer in an armored carriage, which was the only weapon that was not fired with smokeless powder. The congress was closed by the firing of a 12 cm. howitzer in an armored carriage, which latter was set up from its separate parts in less than an hour and a quarter, on that day, and this was accomplished with the simplest tools.

As one would infer from the description of the trials, the shooting grounds of the Gruson Works are equal to two arsenals which are so well supplied that a thorough inspection would absorb a great deal of time.

To the manufacture of hard, cast armor plates was added the production of armored carriages, and the latter led to the manufacture of rapid firing guns for arming the carriages, and so to-day the works offer an opportunity for the careful study, not only of means of defense, but also of some means of attack. In closing our report we would say that, judging from appearances, no guest went away dissatisfied, and cer-

tainly the directors have every reason to be satisfied with the excellent results of their test shooting.—*Illustrirte Zeitung.*

LOADING MATERIALS AND THEIR USES.

LOADING materials are defined as those substances which are added to the pulp in the beater engine, other than pure fiber, and which consequently do not felt together, forming the texture of the sheet of paper.

The opinion is frequently expressed by large consumers of paper that the so-called loading materials are added to the pulp in order to increase its weight, and thereby augment the profits of the manufacturer. When they are used, cheapness is aimed at rather than quality of product. Paper is applied to a multitude of purposes, where great durability is not essential and where cheapness is a necessity before all other requirements.

The chief requisites of a loading material are that it is in a fine state of division, is not acted on by alkalies (resin size), chlorine or acids and does not act disadvantageously on the fiber by altering the strength of the sheet of paper.

Inorganic and organic substances are both used for loading. The former are mainly mineral earths, while the latter are ground wood (mechanical wood pulp) and waste paper. The latter is prepared by grinding very hard sized papers for a long time to a fine powder. The nature of the loading material, and the mode in which it is added to the pulp in the beater engine, influences to a great extent the strength of the paper. The resin size and starch both assist in fastening the loading in the fiber, which, in consequence, loses in softness and suppleness. The finished paper possesses less strength, as the felting capabilities of the individual fibers are reduced. The quantity of loading substances which can be used depends upon the weight and strength of the paper to be made, and also on the nature of the loading itself.

It is necessary to add loading materials to many kinds of paper, in order to increase its absorptiveness. Ordinary news printing paper contains as much as 85 per cent. loading, in the form of mechanical wood pulp and mineral substances, and 15 per cent. of pure fiber. These substances serve to increase its weight and its power to imbibe the printing ink. The preparation of such papers requires much experience, as the large amount of ground wood ordinarily used makes the paper harsher than is desired for the printing type. An addition of some mineral matter is therefore employed to diminish the degree of harshness, and increase its absorptiveness. The small addition of strong pulp (pure fiber) and the consequent low strength of the paper makes it difficult to hit the exact proportion to be used. Experience and long practice can alone guide one to good results. Clay, for example, is added in isolated cases, up to as much as 50 per cent. The paper thus produced absorbs the ink well, and is easily calendered. It yields good printing impressions and the color or ink dries quickly. Soft sized paper of this composition throws off dust, however, during the printing, and easily smears.

Minerals are also added to the pulp to give the paper greater whiteness. The bright appearance which many papers possess in these days, and which are produced from sulphite wood pulp, is increased by the addition of loading minerals. Medium fine writing papers having this appearance should be free from mechanical wood pulp, refuse fiber and minerals. Cotton has the same properties and must also be taken for thin papers, as paper waste and mineral substances part with the water but slowly, so that the web of paper adheres too much to the couch roll or wet press.

Mineral and organic loading substances give to the paper a beautiful clear transparency. The cloudiness produced by too long fiber is diminished by their use. In paper prepared with clay, a low pressure suffices for producing the necessary gloss and smoothness. Clay, however, absorbs moisture from the atmosphere, and as quickly parts with it again on change of temperature, so that the gloss and smoothness of the paper rapidly disappear.

China clay, a loading material in great request among paper makers, is obtained free from sand and grit, from the native clay, by repeated washings. It is almost free from iron. Next to mechanical wood pulp, it is the most extensively used loading in the manufacture of printing papers. Its color, somewhat yellowish at times, answers well the purposes to which it is applied. It is mixed with water to the consistency of thick cream, and is then simply added to the pulp for unsized papers. The loss in the paper machine under such circumstances is large, sometimes more than 50 per cent. To reduce this loss in the preparation of soft sized, *e. g.*, ordinary printing paper, the China clay is first boiled up with starch and frequently with resin size. The fine particles of resin and mineral float in the thick fluid, absorb the resin size and fasten themselves on the fiber. The thin layer of pulp next the wire on the wire cloth more effectually prevents the clay passing away with the water; thus preventing undue loss.

In the preparation of hard sized papers and of writing paper, the addition of China clay is limited. The more clay added to such papers, the less resisting are they toward ink, because the clay itself absorbs a quantity of resin size. The resin and resinate of alumina are altered and are not so suitable for sizing the paper. A writing paper was sized with 3 per cent. resin without the addition of clay, but when loaded with clay as much as 7 per cent. resin was necessary. When clay is introduced into papers, their "body" and appearance are altered.

Hard sized papers are prepared with ground *gypsum* (native sulphate of lime) or "*annaline.*" Gypsum, unlike China clay, does not absorb the resin size, and, consequently, it allows the fiber to receive the full amount of size. Nor does it absorb moisture from the air, and, therefore, the finished paper does not lose its gloss and smoothness so readily. Annaline has also a very pure white color, which it communicates to the paper. Indeed, the value of annaline depends upon its whiteness and upon the degree of fineness to which it has been ground. The finer it is, the better it answers as a loading material. Low or poor qualities yield a rough paper, and there is much loss occasioned by settling in the sand trap of the paper machine. Besides, when the paper is glazed, its surface is covered with fine glistening particles of annaline. When prepared by washing the ground mineral free from grit, and mixing with starch or resin size, it does not give the same results as China clay. It is impossible by the most perfect sifting to obtain it in such a fine state as clay, and as its absorptiveness is less, it is not so much employed for loading printing papers. For writing paper it is better adapted—yielding a somewhat less ragged appearance and firmness.—*Papier Zeitung.*

FIG. 10.—21 CM. BALL MORTAR IN ARMOR STAND.

FIG. 11.—ARMORED TURRET USED AS A STAND FOR SPECTATORS.

PAPER PULPS.

THE woods that are used in the manufacture of paper are treated in two different ways, one mechanical and the other chemical. In the first, soft woods are especially employed, such as the aspen, poplar, etc., and in the second, the fir, and particularly the silver fir, which furnishes a very pure cellulose.

The mechanical pulp is obtained by abrading, on a horizontal grindstone, billets of wood 12 inches in length, arranged in cells, and held in clamps against the perimeter of the stone. A continuous current of water carries along the pulp formed, which is further refined by another mill before it passes to the lixiviators. Norway, which, as is well known, is widely covered with forests, furnishes Europe with a very large quantity of mechanical wood pulp.

The chemical pulp, which was formerly made by treating wood with caustic soda, is now almost universally obtained by the use of bisulphites, and particularly of bisulphite of lime. The process, which appears to have been first adapted to industrial practice by Dr. Mitscherlich, has received various improvements in Sweden, Austria, and France. It gives more economical results than soda, because of the much lower price of the bisulphite of lime.

The wood, which is in general that of the silver fir, is washed and decorticated, and then cut by a circular saw into billets three feet in length, and finally split by a machine. In this state, through the aid of an inclined box, it is presented to a mechanical cutter, composed of a cast steel disk provided with two radial steel blades, and revolving with great rapidity. This machine furnishes 35 cubic feet of wood shavings in the space of six minutes, and these shavings are thrown into baskets, whence they are afterward taken and spread upon a wide table provided with a grating through which the dust passes. The remains of knots or bark that would not be well adapted for treatment with alkali are carefully picked out by women. The shavings are then taken to the first story in baskets, and put into the lixiviating apparatus. As the latter presents a few peculiarities because of the extremely corrosive action of the bisulphite of lime, we shall first speak of the manufacture of the bisulphite. This is obtained by the reaction of sulphurous acid produced either by the roasting of pyrites or by the burning of sulphur upon a column of limestones. The gas traverses this column from bottom to top, and the reaction is facilitated by a showering with water in the opposite direction, and so regulated as to give a lixivium of a proper density.

The bisulphite formed is collected at the base of the column. It is a colorless liquid, of an odor as suffocating as that of sulphurous acid, and attacks all the common metals except lead. So the iron plate lixiviating apparatus have to be provided with a lining of cement, upon which are laid several sheets of lead. Besides, they are inclosed in masonry of refractory bricks, which are themselves covered with lead, and all the openings for the introduction or removal of material are lined with the same metal.

These apparatus, which are of a very large capacity (1,400 to 1,800 cubic feet), are stationary or rotary. A worm made of an alloy of lead and antimony permits of the introduction of steam into the apparatus, in order to raise the bisulphite to a temperature of 130°, but, as the steam might blacken certain parts of the pulp, it is introduced either through a double bottom or through lead worms with which the sides of the apparatus are provided.

The reagent removes the gummy and resinous substances, and these are retained in a residuum of sulphate of lime, while the cellulose remains in a practically pure state. In order to free it from the last traces of acids and resinous substances, it is washed with water, without any trouble being taken to collect the residua which have no value. But the cellulose, which has preserved the appearance of wood, must be reduced to a finer pulp in order that it may be pumped to the purifying apparatus. So, on coming to the lixiviating apparatus it passes into large vats, where it is submitted to the action of an agitator that keeps it constantly in motion. From thence it is forced to the purifiers, which comprise the collectors (long wooden conduits, in which the heavy matters are deposited), and the sifters, which consist of boxes with a movable bottom provided with apertures that let the good pulp pass, and retain all else.

The pulp is finally drained in conical rotary sieves, and can then be directly employed for many papers, such as those on which journals are printed, colored papers, etc.

However, it has to be bleached by the mixtures designed for the finer papers. To this effect there is now used a very ingenious process of electro-chemical bleaching devised by Mr. E. Hermite. It consists in the decomposition of calcium or magnesium chlorides by the passage of an electric current. This forms a liquid possessing a most intense decolorizing power. In the presence of the vegetable fiber, the primitive salt is regenerated in measure as the bleaching proceeds, so that at the end of the operation the same bath can be used again. The sole loss of chloride is what the fiber has taken from the bath. The entire expense, then, is reduced to that occasioned by the production of the motive power necessary to actuate the dynamos, and the keeping of them in repair.

Finally, we may consider the waste of paper mills, or that of the industries that employ paper as a substitute for rags. Old papers are always sorted before being used. Those containing printed matter are first treated with soda before being refined, and then bleached with chlorine. They are afterward taken to granite millstones joined in pairs and running vertically over a third and horizontal stone inclosed in a cast iron vat, into which water is run while the waste is being thrown in. The same operation is applicable

to the Norwegian mechanical pulp, in order to render it finer and more homogeneous.

The various pulps that we have just examined, being obtained either in the same mill or purchased outside, have to be mixed according to the qualities that it is desired to obtain. Delicate fibers, like those of cotton rags, yield a thin pulp and flexible and soft paper. Coarse and strong fibers, like those of hemp and flax, furnish a thick pulp and a transparent and smooth paper. Mechanical wood pulp, the fibers of which are very short, adds opacity and body, but quickly becomes yellow. Cellulose, which forms chemical wood pulp, furnishes an excellent paper, silky and soft to the touch and well adapted for printing. Straw pulp has shorter fibers than those of the preceding, but gives transparency and uniformity. Finally, alfa comes nearest to rags, and constitutes the substitute therefor *par excellence*.

The mixture is made in beating engines, which are established in series of three. It is in these apparatus that the paper is sized in order to render it impermeable to ink. The sizing is done with a resinous soap prepared by melting resin with carbonate of soda. The addition of a little alum to the vat precipitates a resinous compound of alumina, which agglutinates the fibers.

A weighting composed of kaolin, plaster, sulphate of baryta, etc., is used for common papers, of which it corrects the transparency and to which it gives whiteness. From 5 to 20 per cent. of fecula is generally added to it, in order to fix it better to the fibers. Finally, the coloring, when pulps formed of colored rags are not used, which is most generally the case, is done by pouring the colors into the vat through a very fine sieve, or through flannel. The invention of aniline colors, which are always soluble in water, has made this part of the manufacture easy; but these colors are unfortunately sensitive to the action of light. —*Kuhlow.*

SULPHITE PULP BOILING.

An anonymous writer in the *Papier Zeitung*, No. 72, September 7, 1890, referring to the very interesting experiments of Mr. Thilmany, Kaukauna, U. S. A., on the treatment of different kinds of wood in the bisulphite pulp manufacture, an abstract of which appeared in the *Chemical Trade Journal*, vol. vi., 1890, pages 303, 304, gives the following account of a series of experiments done in the laboratory, on the action of sulphite lyes, of pure aqueous solution of sulphurous acid, and of aqueous solutions of the sulphites of calcium, barium, magnesium, sodium and potassium, upon wood and other raw fibrous materials.

With the exception of the *Pinus maritima* and the sugar and Spanish cane (*Saccharum officinarum* and *Calamus rodcutum*), the other woods and fibrous plants were all grown on German soil. As shown in the tables, most of the experiments were carried out at a temperature above 100° Centigrade. In each test the wood and lye were placed in a glass tube, hermetically sealed, and then heated to the required temperature in an oven. The glass tubes easily withstood a pressure of from 3 to 4 atmospheres, and were cooled before opening.

The experiments conducted at a temperature below 100° C. were made in small glass-stoppered tubes, and heated in a water bath.

The following tables embody the results obtained:

"PINUS SYLVESTRIS."

Lye.	Specific Gravity	Time in hours	Temperature Degrees Centigrade.	Boiled Wood, etc.	Remarks.
Calcium sulphite lye	—	12	110–130	half soft	—
"	—	12	about 130	sufficiently boiled	—
"	1·075	6	124·6	"	—
"	—	6	124·6	"	—
"	1·07	6	126·3	"	—
Barium sulphite lye	—	6	124·6	hard, brittle	two tests
"	1·025	6	126·3	not quite boiled	—
"	1·025	16	72	tough	*—
Aqueous sulphurous acid	—	12	110–130	hard, brittle	—
"	—	12	about 130	strongly corroded	—
"	1·025	16	72		
once again	"	15	78·3	tough	*twice boiled
Aqueous sulphurous acid	—	15	78·3	"	

"PINUS STROBUS."

Lye.	Specific Gravity	Time in hours	Temperature Degrees Centigrade.	Boiled Wood, etc.	Remarks.
Calcium sulphite lye	—	12	110–130	soft	—
"	—	12	about 130	over boiled	above test boiled again
"	—	12	about 130	boiled	—
"	1·08	6	120–130	"	—
Ordinary aqueous sulph. acid	—	12	110–130	hard	—
"	—	12	about 130	brown, powder	the last test was boiled twice
"	—	12	"	black, powder	—

"PINUS MARITIMA."

Lye.	Specific Gravity	Time in hours	Temperature Degrees Centigrade.	Boiled Wood, etc.	Remarks.
"A" 25 c.c. calcium sulphite lye	about 6° Bé	36	113·6	hard	10·4 grm. wood
"B" 32 c.c. calcium sulphite lye	6° Bé	36	113·6	brown, hard	14·8 grm. wood
"C" 15 c.c. calcium sulphite lye	6° Bé	36	113·6	hard	5·3 grm. wood
Test "A" with fresh lye	6° Bé	12	116	half boiled	2nd time boiled
Test "C" with fresh lye	6° Bé	12	116	still not quite boiled	"
Test "A" again with fresh lye	6° Bé	12	116–117	soft, but not completely boiled	3rd time boiled
Test "C" again with fresh lye	6° Bé	12	116–117	"	"

"ABIES EXCELSA."

Lye.	Specific Gravity	Time in hours	Temperature Degrees Centigrade.	Boiled Wood, etc.	Remarks.
Calcium sulphite lye	—	12	about 130	boiled	—
" "	1·08	6	120–130	"	—
" "	1·075	6	124·6	"	two tests
" "	1·065	6	126·3	"	with 1% h.I.
" "	1·065	6	126·3	"	" 1% NaCl.
36 c.c. Calcium sulphite lye	1·055	6	126·3	"	5·6 grm. wood
100 c.c. Calcium sulphite lye	1·075	6	125	"	5·0 " "
120 c.c. Calcium sulphite lye	—	2	118	slightly attacked	5·0 " "
22 c.c. Calcium sulphite lye ...... (SO_2 of sp. gr. 1·03 saturated with lime.)	—	6	126·4	not completely boiled	1·2 " "
25 c.c. Calcium sulphite lye ...... (SO_2 of sp. gr. 1·03 with less lime.)	1·035	6	126·4	well boiled	1·25 " "
22 c.c. Calcium sulphite lye ...... (SO_2 of sp. gr. 1·03 + a little $CaSO_3$.)	1·035	8	150	black-brown completely destroyed	1·25 " " $CaSO_3$ separated out
20 c.c. Calcium sulphite lye ...... (SO_2 of sp. gr. 1·03 saturated with lime.)	—	8	150	bright brown, quite soft, over-boiled, covered with hard crust of $CaSO_3$	0·9 grm. wood
14 c.c. Calcium sulphite lye	1·05	36	116·6	white, well boiled	0·25 " "
13 c.c. Calcium sulphite lye	1·05	36	116·6	white, well boiled	0·70 " "
85 c.c. Calcium sulphite lye	1·05	36	116·6	well boiled	2·2 " "
21·5 c.c. Calcium sulphite lye ...... (1% NaCl added.)	1·05	36	116·6	"	5 " "
$CaSO_3$ dissolved in HCl	—	6	126·3	"	—
Magnesium sulphite lye	—	12	110–130	brown, soft	—
Magnesium sulphite lye	—	12	about 130	boiled	—
30 c.c. Magnesium sulphite lye	1·015	6	126·6	nearly boiled	4·5 grm. wood
Barium sulphite ..	—	6	124·6	tough, destroyed	two tests
Potassium sulphite	—	12	about 130	boiled	"
Sodium sulphite ..	—	12	" 130	"	"
Ordinary aqueous SO_2	—	12	" 130	"	—

"LARYX DECIDUA."

Lye.	Specific Gravity	Time in hours	Temperature Degrees Centigrade.	Boiled Wood, etc.	Remarks.
Calcium sulphite ..	—	12	110–130	tough	—
Ordinary aqueous SO_2	—	12	110–130	hard and brittle	—

FAGUS SYLVATICA.

Lye.	Specific Gravity	Time in hours	Temperature Degrees Centigrade.	Boiled Wood, etc.	Remarks.
Calcium sulphite lye	—	12	110–130	quite soft	—
Barium " "	1.025	16	72	brittle	—
Aqueous SO_2	—	12	110–130	strongly corroded	—

BETULA ALBA.

Lye.	Specific Gravity	Time in hours	Temperature Degrees Centigrade.	Boiled Wood, etc.	Remarks.
Calcium sulphite lye	—	16	72	scarcely attacked	twice boiled
" " again	—	15	78·3	tough	

POPULUS.

Lye.	Specific Gravity	Time in hours	Temperature Degrees Centigrade.	Boiled Wood, etc.	Remarks.
Calcium sulphite lye	—	12	about 130	sufficiently boiled	—
" "	1·08	6	120–130	"	—
" "	1·075	6	124·6	"	—
" "	—	6	124·6	"	—
" "	1·07	6	126·3	"	—
Barium "	—	6	124·6	hardly boiled	two tests
" "	1·025	6	126·3	"	—
Aqueous SO_2	—	12	about 130	brown—boiled	—

ABIES CANADENSIS.

Lye.	Specific Gravity	Time in hours	Temperature Degrees Centigrade.	Boiled Wood, etc.	Remarks.
9 c.c. calcium sulphite lye	1·065	6	126·6	sufficiently boiled	1·9 grm. wood
8 c.c. calcium sulphite lye	1·05	6	126·6	"	3 "
5 c.c. calcium sulphite lye	1·04	6	126·6	not quite boiled	0·15 "
35 c.c. calcium sulphite lye	1·055	6	126·6	"	5 "
7 c.c. magnesium sulphite lye	1·015	6	126·6	still, not boiled	0·27 "
12·5 c.c. barium sulphite lye	1·015	6	126·6	brown, destroyed	1·2 "
4 c.c. potassium sulphite lye	1·04	6	126·6	somewhat soft	1·0 "
5·5 c.c. sodium sulphite lye	1·02	6	126·6	do., over boiled	1·33 "
4 c.c. aqueous SO_2 (ordinary)	1·02	6	126·6	brown, brittle	0·07 "
9 c.c. aqueous SO_2 (ordinary)	1·02	6	126·6	"	0·67 "

QUERCUS ROBUR.

Lye.	Specific Gravity	Time in hours	Temperature Degrees Centigrade.	Boiled Wood, etc.	Remarks.
Calcium sulphite lye	1·08	6	120–130	hardly boiled	—
Calcium SO_3, dissolved in H. Cl.	—	6	126·3	still, not quite boiled	—
Sodium sulphite lye	—	12	about 130	half soft	—
" "	—	12	" 130	not quite boiled	—

LINUM USITATISSIMUM (FLAX).

Lye.	Specific Gravity	Time in hours	Temperature Degrees Centigrade.	Boiled Wood, etc.	Remarks.
Calcium sulphite lye	1·08	6	120–130	sufficiently boiled	—
" "	—	16	72	somewhat soft	boiled again
" " second time	—	15	78·3	still tough	boiled twice

ORDINARY STRAW.

Lye.	Specific Gravity	Time in hours	Temperature Degrees Centigrade.	Boiled Wood, etc.	Remarks.
Calcium sulphite lye	1·08	6	120–130	soft	—
Barium "	1·025	16	72	somewhat soft	—
Aqueous SO_2	1·025	15	78·3	not quite boiled	boiled a second time
" "	—	15	78·3	soft, quite boiled	—

SACCHARUM OFFICINARUM (SUGAR CANE).

Lye.	Specific Gravity	Time in hours	Temperature Degrees Centigrade.	Boiled Wood, etc.	Remarks.
Calcium sulphite lye	—	12½	120–130	overboiled	—
" "	—	12	about 130	sufficiently boiled	—
" "	—	15	78·3	tough	—
Barium "	—	15	78·3	tolerably soft	—
Aqueous SO_2	—	12	about 130	sufficiently boiled	—

CALANIUS RUDENTUM (SPANISH CANE).

Lye.	Specific Gravity	Time in hours	Temperature Degrees Centigrade.	Boiled Wood, etc.	Remarks.
Calcium sulphite lye	1·08	6	120–130	sufficiently boiled	—

Both of the tests of *Abies excelsa* were intentionally heated to 150° C., and as cellulose manufacturers express themselves, were "*over-boiled*," that is to say, the action of the lye was too great, due to too long boiling, or to too high a temperature. Sulphite of lime separated out as a precipitate in both cases.

The barium sulphite lyes used in the experiments were formed by dissolving barium oxide in aqueous sulphurous acid, and were very weak, as sulphurous acid dissolves but little of the base.

From the experiments the author arrives at the following conclusions, viz.:

In the boilings conducted below 100° C., all the wood experiments remained hard and tough. The other fibrous plants, *e. g.*, flax, straw, etc., were only half soft.

In those experiments conducted above 100° C., the woods treated with pure aqueous sulphurous acid were brown, and all tests, besides *Abies excelsa populus* and sugar cane, *Saccharum officinarum*, remained hard or were brittle. On the contrary, the woods treated with metallic sulphite lyes were mostly white. With calcium sulphite lye nearly all the woods were soft, white, and sufficiently boiled. Excepting *Abies excelsa*, the whitest was the *populus*, while *Laryx decidua* (larch, a strongly resinous wood) remained tough. *Pinus maritima* always remained hard and yielded a strongly aromatic odor and a sticky or viscous lye. *Quercus robus* (oak), as is well known, is with difficulty boiled by the bisulphite methods. With magnesium, potassium and sodium sulphite lyes, the wood remained almost always soft, or tolerably soft, while with weak barium sulphite lye the woods were tough and hard. With this reagent the *populus* was easily boiled, yielding soft white fiber. —*Chem. Trade Jour.*

THE NEW HYDRAULIC LABORATORY OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

By GEORGE F. SWAIN, Hayward Professor of Civil Engineering.

THE erection of the new engineering building of the Institute of Technology, to be occupied by the departments of Civil and Mechanical Engineering, offered an opportunity for a considerable extension in the engineering laboratories, and an attempt has been made to improve this opportunity by laying the foundation for a laboratory for hydraulic experiments, which should be so arranged as to permit of the carrying out of any experiments in hydraulics which it is practicable to perform within walls. Hydraulic experiments on a large scale must necessarily be performed out of doors, since the measurement of large quantities of water requires apparatus and appliances which cannot be accommodated within walls. Thus, the weir experiments of Mr. Francis, at Lowell, were made by taking the water from one of the canals, and using a lock as a measuring basin. Those of Messrs. Fteley and Stearns, at South Framingham, were made by using a portion of the Sudbury River Aqueduct as a measuring basin; the orifice experiments of General Ellis, at Holyoke, were made in connection with the fall between two levels of the canal at that place; and the recent elaborate and careful experiments by Mr. Freeman on the flow of water through fire hose, the discharge of nozzles, and the height of jets were made at Lawrence, where the hydrant system of one of the mills, as well as the city water supply, could be made use of.

But while experiments such as these are clearly excluded from among those which can be made in connection with a hydraulic laboratory in an institution of learning, there remain a large number which can properly be conducted within doors with the aid of suitable apparatus, and which, though they may be

on a small scale as regards the quantities of water employed, nevertheless offer a large field for scientific investigation. The new laboratory of the institute, as already stated, has been planned with a view to affording opportunity, as the work is extended, for carrying on any experiments which are thus practicable; that is to say, in the following directions:

1. Experiments on the flow through orifices of small size, both free and submerged, and either sharp-edged, rounded, or fitted with inside or outside mouth pieces of various kinds, and under heads ranging as high as above seventy feet.
2. Experiments on the flow of water over weirs of small size, either free or submerged.
3. Experiments on the loss of head in small pipes of various kinds.
4. Experiments on the loss of head due to bends, curves, valves, diaphragms, or other obstructions causing sudden changes of velocity.
5. Experiments on the distribution of velocity in different parts of a liquid cross section, either of a jet from an orifice, of a sheet discharged over a weir, or of a liquid flowing in a pipe.
6. Experiments on different water meters, including Mr. Herschel's Venturi meter, as well as the ordinary forms in the market.
7. The testing of small turbines and of various other small motors.
8. Experiments on the pressure of jets against plane or curved surfaces, and on the resistance of standing water to the motion of surfaces of different shapes through it.
9. Experiments on the siphonage of traps, and on other matters connected with plumbing arrangements of houses.—*Tech. Quarterly.*

NOTES ON THE VULCANIZATION AND DECAY OF INDIA RUBBER.*

UNDER ordinary conditions, India rubber for vulcanizing is usually mixed with sulphur and heated to a high temperature, when chemical combination takes place between the sulphur and the rubber, producing a much more valuable compound for ordinary purposes than unvulcanized rubber, the former remaining soft at very low temperatures and firm at high temperatures, while the latter becomes hard and quite plastic respectively at those temperatures.

In making cloth for waterproof garments, another method is employed for vulcanizing the rubber, viz., by wetting its surface with a mixture of somewhere about five to ten parts of chloride of sulphur, dissolved in 100 parts of bisulphide of carbon, and then heating the fabric gently to evaporate away the excess of these substances. The rubber-covered cloth cannot be heated to a high temperature like the rubber alone, because the heat would be liable to injure the cotton, silk or wool of the fabric or destroy or injure the colors.

The bisulphide of carbon softens and penetrates the fine layer of rubber, carrying with it the chloride of sulphur dissolved in it, and it is generally supposed that the chloride of sulphur breaks up, the sulphur combining with the rubber, producing vulcanization, and the chlorine combining with the hydrogen producing hydrochlorene acid, which is liberated. This reaction is clearly not the correct one, and it is probable that the reverse is more in accordance with the facts, viz., that the chlorine of the sulphur chloride combines with the rubber, producing vulcanization, leaving the sulphur in the free state or only partially in combination with the rubber, because in rubber vulcanized by the cold process I have found free sulphur to be present.

From a piece of rubber-covered cloth I separated the rubber, and submitted it to analysis by mixing it thoroughly in small pieces with pure sodium carbonate and igniting, then dissolving the whole in water, and adding to it peroxide of hydrogen previously treated with excess of barium chloride (to separate sulphuric acid or sulphates). The peroxide insures the conversion of the lower oxides of sulphur into sulphuric acid, while the excess of barium chlorides precipitates the sulphuric acid in the solution, which is then weighed as barium sulphate. Another portion of the made-up solution was neutralized, and the chlorine present titrated.

The rubber, previous to ignition, as above described, had been well boiled in water and dried to separate any hydrochloric acid which might be present, but only a faint trace of chlorine compound could be thus separated from the rubber. The total sulphur present in the rubber amounted to 2·60, and the total chlorine to 6·31 per cent.

The yellow-colored sulphur protochloride is best adapted for vulcanizing, because it does not act too strongly upon the rubber, while the dark-colored chloride of sulphur, containing, as it does, a large quantity of the higher chorides of sulphur, is liable to render the rubber quite hard by vulcanizing it too much.

The theory generally adopted to explain this is that these higher chlorides break up easily, liberating their sulphur, which thus combines in greater quantity with the rubber. But my experiments and analyses prove that it is chiefly the chlorine and not the sulphur of the chloride of sulphur which produces the vulcanization.

A rubber substitute much used at present is produced by acting on vegetable oils, such as rape, linseed, etc., with a mixture of chloride of sulphur and bisulphide of carbon. The oil becomes converted into a solid substance resembling India rubber to some extent, but being much more brittle. This body is now used in large quantity for mixing with India rubber for the purpose of cheapening its production. On analysis of some samples of this material, I have invariably found that it contained a much greater proportion of chlorine than of sulphur, and this process, therefore, is a vulcanization by chlorine rather than by sulphur. Recently, I analyzed three samples of rubber substitute, the one termed "special," another "spongy" India rubber substitute, the third being similar to the first in appearance. The first contained of sulphur 3·4 and of chlorine 7·6 per cent. The second contained of sulphur 4·56 and of chlorine 8·22, and the third 2·67 of sulphur and 7·90 of chlorine per cent. These rubber substitutes contain considerable quantities of oily matters soluble in ether, which I have also found to be chlorine and sulphur compounds of the oils.

The first yielded 20·0 per cent., the second 14·3, and the third 11·3 per cent. of these thick oily matters soluble in ether. This oily substance from the first sample contained 2·6 per cent. of sulphur and 6·1 per cent. of chlorine, while that from the second contained 2·97 and 6·87 per cent. of sulphur and chlorine respectively. Some rubber manufacturers regard this oily matter as injurious to the rubber, and reject any substitute which contains any considerable proportion of it.

I have found, however, by experiment that this oily compound, instead of acting injuriously on India rubber, actually acts as a preservative of it. Some rubber threads were smeared with this oily extract, some with ordinary (unvulcanized) rape oil, and some left untreated. These were put into an incubator at 150° Fahr. for a few days, when it was found that the oil-treated rubber was quite soft and rotten, while the other two had remained sound. After a few days more, the original rubber threads had become quite rotten, while the threads smeared with the oily part of the vulcanized oil remained quite sound. The first and second samples of rubber substitutes were examined for soluble chlorides or hydrochloric acid, by boiling in water. The first gave 0·18 per cent. of chlorine soluble in water and the second 0·05 per cent.

It has been known for some time that copper salts exert a most injurious influence on India rubber. Copper salts are sometimes used in dyeing cloth, which are afterward employed for waterproofing with India rubber, and it seems quite astonishing what a small quantity of copper is required to harden and destroy the rubber, and the destructive effect of copper is further enhanced if the cloth contains oily matters in which the copper has dissolved. As an example, a piece of cloth was alleged to have damaged the thin coating of India rubber on it. I found it to contain copper and, with a view of demonstrating this point, I took one piece in its original condition. To the end of this I pasted a similar piece of the cloth from which the oily and greasy matters had been removed by ether, and to the end of this again I pasted another piece of the same cloth from which I had removed both oily and greasy matters and copper. These three pieces, joined end to end into one, were then coated in the usual way with India rubber, and then hung in an incubator at 150° Fahr. In the course of a few days the rubber on the original cloth had become soft, and it then hardened and became rotten and useless. The second piece, from which the greasy matters had been removed, then became quite hard and rotten, while the part from which both greasy matters and copper had been removed has remained in a perfectly elastic and good condition. Professor Dewar observed accidentally that metallic copper, when heated to the temperature of boiling water in contact with the rubber, exerted a destructive effect upon it. With a view of finding whether this was due to the copper *per se* or to its power of conducting heat more rapidly to the rubber, I laid a sheet of rubber on a plate of glass, and on it placed four clean disks, one of copper, one of platinum, one of zinc, and one of silver.

After a few days in an incubator at 150° Fahr. the rubber under the copper had become quite hard, that under the platinum had become slightly affected and hardened at different parts, while the rubber under the silver and under the zinc remained quite sound and elastic. This would infer that the pure metallic copper had exerted a great oxidizing effect on the rubber, the platinum had exerted a slight effect, while the zinc and silver respectively had had no injurious influence on it. A still more curious result was this, that the rubber thus hardened by the copper contained no appreciable trace of copper. The copper, therefore, presumably sets up the oxidizing action in the rubber without itself permeating it. I have pleasure in acknowledging the assistance rendered to me in this investigation by my assistant, Mr. Frederick Lewis.

* Read by Mr. William Thomson, F.R.S.Ed., F.C.S., before the Chemical Section of the British Association.

STAG HUNTING REPRODUCED BY PHOTOGRAPHY.

ONE of the most skillful members of the Excursion Society of the Amateurs of Photography, Mr. Henri Desmarest, an enthusiastic hunter, has devoted himself to the specialty of representing hunting scenes by photography. He has succeeded most remarkably, and the specimens that he exhibited at the photographic section of the Exposition of 1889 were highly appreciated. We publish herewith a *fac-simile* of an instantaneous photograph by Mr. Desmarest which represents the closing scene in a stag hunt. The following are a few data as to the episode represented.

The equipage of Rallye-Bersay, belonging to the Duke of Gramont, had, on the 11th of February, 1890, one of the finest hunts of the season. Two stags, attacked near Croix de Toulouse, were soon separated by the dogs, which rallied upon the finer stag. The animal, after allowing itself to be pursued in the Cassepot rock, the Ecouettes, and the Saint Germain rock, traversed the Melun road, showed up on the side of Butte Saint Louis, and returned to the circumference of attack in order to reach the pond of Bois-le-Roi, which was completely frozen over, and the ice of which gave way under his feet. In this pond, at 3 o'clock, a magnificent death struggle took place after a very spirited run. The animal at bay, surrounded by forty dogs, tried in vain to escape into that part of the pond that had become free through the breakage of the ice. One of the hunters put an end to his agony by a shot from a carbine.

The photograph that we reproduce was taken at 3 o'clock in the afternoon, the sun being low. The objective was a Dallmeyer rapid rectilinear with a focal length of 38 cm.; diaphragm of 14 mm. The shutter employed was that of Messrs. Londe & Dessoudix. The developing was done by hydroquinone.—*La Nature.*

CLOSING SCENE IN A STAG HUNT.

THE UNITED FORGE MASTERS' ASSOCIATION.

THE annual meeting of the United Forge Masters' Association was held at the Gilsey House, New York City. The following officers were elected for the ensuing year: Capt. L. M. Coe, Cleveland, president; W. S. Sizer, Buffalo, vice-president; F. L. Alcott, Cleveland, commissioner; executive committee — Joseph Howard, Buffalo; W. F. Pinkham, New York; J. Johnston, New York.

President Coe delivered the following address:

Gentlemen of the United Forge Masters' Association: It gives me great pleasure to meet again the members of this association at the beginning of another year in the history of our body. The expectations of the friends of our union and society have been more than fulfilled, and we look with pride and satisfaction at the public and private benefits that have resulted in securing higher perfection in our productions, as well as a more uniform standard of excellence. Instead of a sharp competitive strife as to which of us can furnish the largest amount or the cheapest work in the market, resulting oftentimes in the production and sale of imperfectly manufactured articles, the greatest efforts have been put forth to secure to the public the finest and most perfect forge materials known to science or the trade. The United States now takes its place among the foremost manufacturing companies in the world in this our special branch of industry. Our heavy forgings are unsurpassed in excellence, and now float in every inland sea and ocean in almost every part of the globe.

Let it be in the future our highest object to extend and perfect our manufactures, avail ourselves of every new improvement in our forgings that will add to their strength and durability and usefulness. We live in the richest as well as in the largest manufacturing country in the world; our soil is as remarkable for what it contains as what it produces on its surface. We mine annually one half the gold and silver product of the earth. In 1870 we produced 4,500,000 tons of iron ore; we now mine iron ore in 23 States, and in 1880 the total product was 9,500,000, or an increase of 110 per cent. In 1880 our manufactures exceeded in value those of Great Britain by $650,000,000. In all this vast growth and development of the material

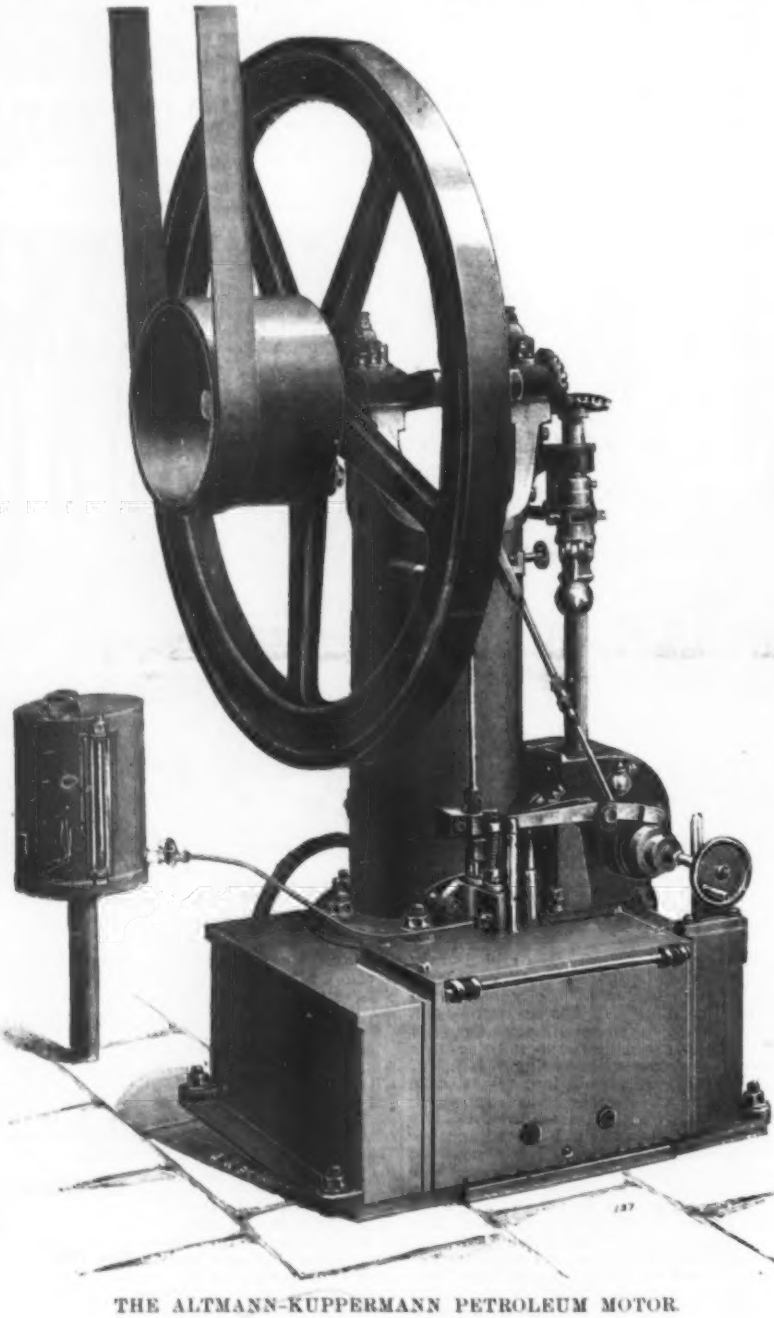
wealth of our country the members of the Forge Association have borne a conspicuous part.

I congratulate you to-day upon the growing ingenuity and intelligence of the vast body of operatives in your employ, as well as the distinguished place you occupy among the useful and influential men of the nation.

Gentlemen, let it be our constant effort to enlarge the borders of our usefulness, increase the means of developing the resources of our common country, and with genuine patriotic pride strive to make the United States the unrivaled workshop for forgings among all nations. In union, there is strength, in knowledge, power, and in fidelity, success. In the black clouds of smoke that envelop our forges we may see the silver lining that irradiates our homes, lights with good cheer the households of our workingmen and adds another luster to the stars that sparkle on the flag of the republic.

THE ALTMANN-KUPPERMANN PETROLEUM MOTOR.

A PETROLEUM motor is practically a gas engine that is independent of a gas works. It makes its own gas



THE ALTMANN-KUPPERMANN PETROLEUM MOTOR.

(or vapor) from the paraffin oil of commerce, and as this can be bought in the remotest spot where civilization has taken root, there is no place where power is wanted that the petroleum motor may not be used. The trials at Plymouth showed that it needs only about one fourth of the weight of fuel of the best steam engine of the same size, while it can hold its own in this respect with the largest marine engines of most recent construction. No wonder that with so wide a market many inventors should be endeavoring to eliminate the defects that have hitherto impeded the progress of this handy form of motor. We have in previous issues given particulars of several designs of petroleum motors, and now publish an illustration on the present page showing the engine of Messrs. Altmann and Kuppermann, of Berlin, which is made in various sizes from ½ horse power to 16 horse power, that shown being of 2 horse power. The features sought to be embodied in this design are simplicity of construction, ease of management, and accessibility of parts. The cycle is that of the Otto engine, which, by the expiration of the patent, has become open to all inventors. The cylinder is vertical and single acting, containing a long piston, packed with five rings to efficiently prevent the leakage of the products of combustion. The cylinder is surrounded with a water jacket in the usual way; at its upper part it has two horns, which carry the bearings of the crankshaft, at one end of which are a flywheel and driving pulley, and at the other end a bevel wheel which drives the governor and the valve gear. The valves are of very simple construction, and are all of the mushroom type; there is a vapor inlet valve, an air inlet valve, and an exhaust valve, each worked by a separate cam on a small horizontal shaft driven from the lower end of the governor spindle.

The store of oil for the day's working is kept in the vessel shown to the left of the view. This is provided with a gauge glass to show the amount of its contents, which are the ordinary paraffin or kerosene, costing 6½d. to 7d. a gallon. No light oil or benzine is required, and consequently no objection is raised by the local authorities, or the insurance companies, to the use of the engine, or to the storage of any reasonable amount of the oil. A pipe leads from the vessel to a small pump, which makes one stroke for every two revolutions of the engine. The length of stroke can be varied by means of a link and sliding block to adjust the richness of the charge to the amount of work to be done. The general control of the engine is effected, however, by the governor, which entirely cuts off the supply of oil when the speed is too high.

To this end a small valve is placed in front of he pump and is kept down by a strong spring; this valve is lifted by a cam to allow the oil to pass to the pump during normal working. But if the speed is too high, the governor shifts the cam sideways so that its raised portion no longer comes under the roller at the end of the lever which controls the valve, and consequently the latter cannot open. The oil which passes the pump enters a small copper retort kept red hot by means of a lamp, and is there converted into vapor, which is drawn into the cylinder when the vapor valve is lifted by its cam. This is the same cam that operates the oil control valve The ignition of the charge is effected in the usual way by means of an incandescent tube, heated in the first instance by the same lamp as the retort. This lamp has no chimney, and burns ordinary paraffin oil with a blue flame like a Bunsen gas jet. The oil is forced through the nozzle by air pressure created by a small pump, and is vaporized by coming into contact with a hot metal spreader. The exhaust valve is not visible in the engraving, as it is at the back of the cylinder. It is worked by a cam, and can be readily removed for cleaning.

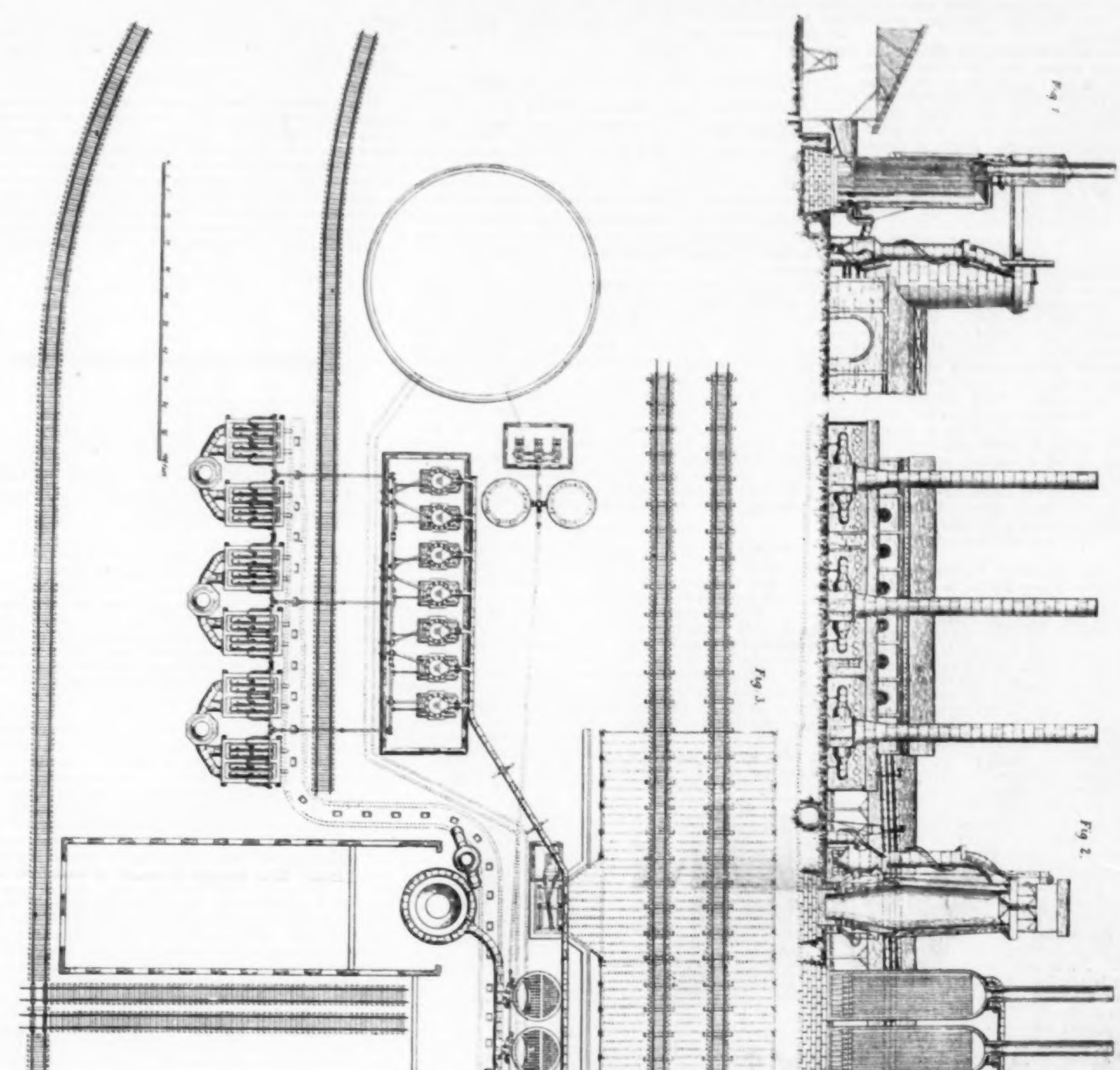
We are informed that the consumption of oil per horse power hour is 0·7 to 0·9 liter (from 0·154 to 0·198 gallon) in the smaller sizes of one or two horse power, and 0·5 to 0·6 liter (from 0·110 to 0·132 gallon) in the larger sizes. These are very good results, and if they can be obtained in daily practice, the engine should take a high position for economy, as it does for simplicity.—*Engineering.*

BLAST FURNACES AT SHEFFIELD, ALABAMA.

As an illustration of the activity that now characterizes the great iron and coal districts of Alabama, that have during the last few years attracted so much interest in England and so much British capital, we propose to publish a somewhat detailed description of the blast furnace plant belonging to the Sheffield and Birmingham Coal, Iron and Railroad Company, of Sheffield, Alabama. We should mention that this plant has been in operation for about two years, and was among the first of importance constructed in the district. The plant consists of three furnaces, each 18 ft. in diameter of bosh and 75 ft. high, situated at Sheffield, Colbert County, Alabama. The furnaces were designed for a combined capacity of 450 tons of iron per day. The coke supply is obtained from the company's own mines at Jasper, Alabama, although they are conveniently located to receive the Birmingham and Pocahontas coal and coke. The iron and limestone supplies are also conveniently situated to the furnace. The finished product can be shipped to the Western and Northern pig iron markets, either by railroad or by steamer *via* the Tennessee River. The plant being situated at the head of navigation of this river, has direct connection with the Ohio and Mississippi rivers, besides having excellent railroad facilities. All the upper part of the State of Alabama is penetrated by the great mineral veins that reach down diagonally from the north; these are the great basis of the immense iron and coal industries of Pennsylvania, and running through Virginia and Western North Carolina, Tennessee, and Georgia, terminate in rich outcroppings at about the center of Alabama. A vast triangular tract in the upper part of the State is known as the Warrior coalfield, because the Warrior River runs over the main portion. North of this and forming the base of the triangle are immense deposits of hematite iron ore. Just north of this base flows the Tennessee, and Sheffield, located between the iron and coal and the river, stands ready to convert the ore into a marketable product and to ship it to the points of demand. As shown in our page plate, each furnace is 18 ft. in diameter at the bosh and 75 ft. high, and is supported upon eight cast iron columns 18 ft. high and 18 in. in diameter. On the top of each column is bolted a cast iron bracket, to which the mantel and bosh casing is riveted. The casing is made of wrought iron 23 ft. in diameter at the bottom and 20 ft. 3 in. in diameter at the top, the plate iron being in. and $\frac{5}{16}$ in. thick. The platform on top of the casing is 20 ft. 3 in. in diameter, made of $\frac{5}{16}$ in. plate iron. A wrought iron guard 42 in. high surrounds this platform. The furnace top is connected to the wrought iron hoist tower with a bridge 30 ft. long and 15 ft. wide. The beams of this bridge are 15 in. deep. It is surrounded with a wrought iron guard, 42 in. high, made of one-eighth inch plate iron. The hopper is made of cast iron 13 ft. 6 in. in diameter and 38 inches deep. A cast iron lip ring, 1½ in. thick, is fitted in this hopper. Its lower edge is machined to fit the bell. An arch is erected over this hopper, upon which are pivoted levers for raising and lowering the bell. A steam cylinder is attached to one of these levers, by means of which the bell is operated. The brick bosh of the furnace is protected by water-cooled plates, the great advantage of this plan over the old method of construction being, first, that the water-cooled castings can be examined at any time for leaks, by simply driving a bar a short distance into the brickwork. Consequently, if the leak is found, the plate can be removed without tearing out the brickwork.

The bustle pipe surrounds the columns of the furnace, and is 30 in. in diameter. Seven revolving ball-jointed tuyere stocks are attached to this bustle pipe. These tuyere stocks are lined with firebrick. Seven tuyere arches made of coiled gas pipe are inserted in each hearth bottom, and in each tuyere arch is fitted a 6 in. phosphor-bronze tuyere. To carry away the gases from these furnaces, a down-comer 76 in. in diameter is attached to each furnace. On the bottom of this down-comer is constructed a circular dust catcher, 11 ft. 9 in. in diameter and about 18 ft. long. A bell and hopper is inserted in the conical bottom of this dust catcher, through which the dust is drawn from the top of the cylindrical portion of the dust catcher. Two down-take pipes convey the gas into the underground flues. A circular stairway is secured to the down-comer, extending from the hearth level to the platform level of the furnace. The hearth bottom is 45 in. thick, composed of two layers of conical shaped blocks. The hearth and bosh walls are 27 in. thick, laid in alternate courses, with 13½ in. and 9 in. brick. The in-wall is 22½ in. thick, laid with 13½ in. and 9 in. brick. This in-wall is backed with 9 in. of No. 2 firebrick. The hoist towers are wrought iron structures, extending from the floor of the stockhouse to the platform level. The columns are made of two 8 in. channel irons latticed to each other These columns are stayed at intervals of 10 ft. with eye beam struts, and tie bars, provided with turn buckles. The platforms are 7 ft. wide and 7 ft. long, and are connected to the engine drums by means of 1 in. cables. These platforms or guides are also fitted with safety catches or pawls.

The hoist engine is of the duplex vertical automatic type, with 12 in. diameter cylinders and 10 in. stroke. These engines are located in a small brick building, erected upon the ground level on one side of the hoist towers. Each of the furnaces is equipped with three 20 ft. by 65 ft. Gordon-Whitwell-Cowper firebrick hot-blast stoves. These stoves are of the three-pass type. The gas is admitted through a valve into the base of the combustion chamber, and passing up this chamber descends through a series of regenerative flues into a second up-pass of regenerative work, and then directly to the atmosphere through a small draught stack erected upon each stove casing. This type of stove has advantages over the four-pass system, since the resistance to the flow of gas due to the long contracted passes of the four-pass system requires enormous underground flues and draught stacks, whereas in this type each stove is provided with its own draught stack, and avoids the costly construction necessitated in the four-pass system. The hot blast valves are of the gate type, the seat being a hollow phosphor bronze



BLAST FURNACE PLANT AT SHEFFIELD, ALABAMA, U.S.A.

DESIGNED FOR THE SHEFFIELD AND BIRMINGHAM COAL, IRON AND RAILROAD COMPANY BY MESSRS GORDON, STROBEL AND LAUREAU, ENGINEERS, PHILADELPHIA.

casting, fitted into the valve body. A cap is bolted to one end of this body, and if the valve seat should get out of line or be destroyed, it can be removed through this cap and a new seat may be inserted. The air valve, which is of the poppet form, is attached to a hinged door, and also forms an opening in the bottom of the combustion chamber, for the removal of the dirt. The chimneys of these stoves are strongly built, commencing with heavy plate iron at their base and gradually thinning at the top, each chimney being lined with 4½ in. of firebrick.

The cold blast valve is an ordinary slide gate valve, operated with a rack and pinion, and is attached to the base of the chimney on the top of the stove. The chimney valve is placed in the bottom of the chimney, and is of the sliding gate type, the valve seat being made hollow to permit of a strong current of air passing through it for cooling purposes. Each of these stoves has a heating surface of 25,000 square feet, and three stoves are designed to heat 25,000 cubic feet of blast to a temperature of 1,400 deg. per minute. The plant is equipped with seven variable cut-off steam blowing engines, each with a blast cylinder 84 in. in diameter, steam cylinder 36 in. in diameter and 48 in. stroke. The bedplates are of the box form, that is, the cross sections of the sides and ends are nearly rectangular. The bottoms are flat, that the foundations may be made solid and the casting bedded true. The housings or frames are of the box form. The blast piston head is provided with two piston rods, and the steam piston with one rod, all of which are fitted into a wrought iron crosshead, with tapered ends, and secured by nuts. Each of the fly wheels weighs ten tons, and is made in two pieces, fitted together by means of center plates. These center plates are fitted and keyed upon a wrought iron shaft, 12 in. in diameter, the crank pins being securely fitted into each disk plate after the same are keyed upon the main shaft, thus insuring accuracy in radial distance and alignment. The blowing cylinders are 84 in. in diameter, the inlet and outlet valves being so disposed that the least possible dead space or clearance is secured. Each valve seats by gravity, requiring neither springs nor counterweights.

There are 143 inlet and 80 outlet valves to each blowing engine, each valve being 4½ in. in diameter. The inlet valves are made of the best sole leather, and rise from their seats with the slightest current of air. The outlet valves are lifted from their seats as easily as the inlet valves, but are slightly heavier, being made of steel, one-sixteenth inch thick. Each valve seat is independent of the cylinder head, and can be removed quickly should it be found necessary to insert a new leather valve. Each engine weighs 150,000 lb., and at 50 revolutions has a displacement of 15,392 cubic feet of blast per minute. The casting houses are 50 ft. span and 150 ft. long. The walls are made of brick, 25 ft. high, and are provided with openings and ventilating windows. The roof trusses are made of iron, the whole being covered with No. 20 corrugated iron. A ventilator 6 ft. wide extends over all the trusses except one. The roof truss is made sufficiently heavy to carry a load of 1½ tons of pig iron upon a trolley truck, attached to it. Two of these trucks are attached to each roof truss, and by this means the pig metal is carried out of the cast house and arranged to be dumped upon a car located on a track outside of the building.

The boilers are of the water tube type, the total heating surface of the plant for the three furnaces being 21,480 square feet. There are twelve boilers arranged or set in three batteries. Each boiler is composed of ten sections of 4 in. in diameter lap-welded wrought iron tubes, 18 ft. long. Each header is provided with manholes, placed opposite to each tube, and of sufficient size to permit of the cleansing, removing, and renewal of the tube through it. Four steam drums, 30 in. in diameter and 18 ft. 7 in. long, are supplied to each battery of boilers.

The boilers are supported by wrought iron beams, set on iron columns, so that they shall be sustained entirely independent of the brickwork, and be free to expand or contract without affecting the latter. Each boiler is provided with steam gauges, stand pipe, check valves, and other fittings. Each battery of boilers is provided with a gas burner and a set of ordinary grate bars and firing doors. The engine house is a brick building, 124 ft. long by 30 ft. wide, and 30 ft. high over the ground line to the east of the building. The walls are 13½ in. thick, with 4½ in. piers.

The floor of this building is made of 2 in. yellow pine, spiked to 14 in. by 3 in. joists. The roof is a frame structure, made sufficiently heavy to allow of the heaviest part of the blowing engine to be lifted from it. The boiler feed pumps are of the duplex plunger type, each pump having a 12 in. cylinder, 7 in. water plunger, and 10 in. stroke.

Each blowing engine is connected with a feed water heater 34 in. in diameter and 10 ft. high. Each heater contains thirty 2 in. corrugated copper tubes. The top head of the heater is arranged so that it can be swung to one side with a crane, permitting easy access to the tubes for cleansing purposes. The water supply for the plant is obtained from the Tennessee River. On the river bank is sunk a well 17 ft in diameter and 26 ft. high, the bottom of this well being 4 ft. above low water mark. This well is built of heavy wrought iron, and stiffened by means of angle bars. In the bottom of the well are secured two duplex steam pumps, with 18 in. steam cylinders, 12 in. water piston, and 10 in. stroke. Each of these pumps has an 8 in. suction and a 7 in. discharge. The discharge pipes from both of the pumps are led by a 10 in. pipe to a reservoir located on the top of the bank. This reservoir is 90 ft. in diameter and 6 ft. deep, divided into two parts for the purpose of filtering and cooling the water. From this reservoir the water is drawn by three duplex pumps, the steam cylinders of which are 18 in. in diameter, water piston 12 in. in diameter, and stroke 10. These pumps discharge through a 12 in. pipe into the water tanks, or directly to the furnace.

There are two water tanks, each 15 ft. in diameter and 20 ft. high, made of plate iron ⅜ in. thick. These tanks are supported on sixteen cast iron columns 30 ft. high. The stockhouse is a frame structure 70 ft. span from center to center of posts, and 400 ft. long from end to end. The posts are made of 10 in. by 10 in. yellow pine, and are 30 ft. high, strongly braced with lateral trusses. The rafters of the roof are made of 7 in. by 8 in. timbers, trussed and bound together with wrought iron bolts. These rafters are covered with a No. 24 corrugated iron roof. The rafters and roof extend 6 ft. over each side of the building, thus making the covered surface 82 ft. wide by 400 ft. long. The flooring is made of 2 in. planks, spiked to 5 in. by 5 in. joists or stringers. The charging scales are disposed at different points in this house. Two railroad trestles, about 12 ft. high, extend through this building. The entire plant, including the excavations for foundations and the foundations themselves, was designed and constructed by the firm of Messrs. Gordon, Strobel & Laureau, limited, of Philadelphia, Pa.—*Engineering.*

[Continued from SUPPLEMENT, No. 778, page 12438.]

THE ELECTROMAGNET.*

By Professor SILVANUS P. THOMPSON, D.Sc., B.A., M.I.E.E.

I.

GENERALITIES CONCERNING ELECTROMAGNETS.

Materials.—In any complete treatise on the electromagnet it would be needful to enumerate, and to discuss in detail, the several constructive features of the apparatus.

Three classes of material enter into its construction. First, the iron which constitutes the material of the magnetic circuit, including the armature as well as the cores on which the coils are wound, and the yoke that connects them. Secondly, the copper which is employed as the material which conducts the electric currents, and which is usually in the form of wire. Thirdly, the insulating material employed to prevent the copper coils from coming into contact with one another or with the iron core. There is a further subject for discussion in the bobbins, formers, or frames upon which the coils are in so many cases wound, and which may in some cases be made in metal, but often are not. The engineering of the electromagnet might well furnish matter for a special chapter.

TYPICAL FORMS.

It is difficult to devise a satisfactory or exhaustive classification of the varied forms which the electromagnet has assumed. But it is at least possible to enumerate some of the typical forms.

1. *Bar Electromagnet.*—This consists of a single straight core (whether solid, tubular or laminated) surrounded by a coil. Fig. 3 depicts Sturgeon's earliest example.

2. *Horse-shoe Electromagnet.*—There are two subtypes included in this name. The original electromagnet of Sturgeon (Fig. 1) really resembled a horse-shoe in form, constructed of a single piece of round wrought iron, about half an inch in diameter, and nearly a foot long, bent into an arch. In recent years the other subtype has prevailed, consisting, as shown in Fig. 11, of

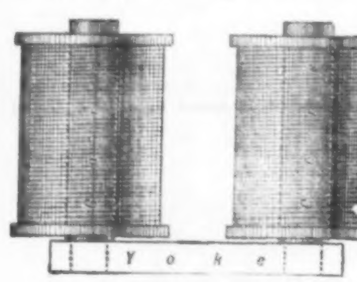


FIG. 11.—TYPICAL TWO-POLE ELECTROMAGNET.

two separate iron cores, usually cut from circular rod, fixed into a third piece of wrought iron, the yoke. Occasionally this form is modified by the use of one coil only, the second core being left uncovered. This form has received in France the name of *aimant boiteux.* Its merits will be considered later. Sometimes a single coil is wound upon the yoke, the two limbs being uncovered.

3. *Iron-clad Electromagnet.*—This form, which has many times been re-invented, differs from the simple bar magnet in having an iron shell or casing external to the coils, and attached to the core at one end. Such a magnet presents, as depicted in Fig. 12, a central

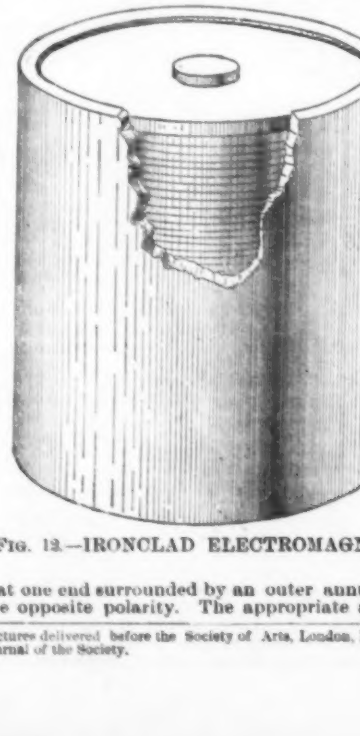


FIG. 12.—IRONCLAD ELECTROMAGNET.

pole at one end surrounded by an outer annular pole of the opposite polarity. The appropriate armature for electromagnets of this type is a circular disk or lid of iron.

4. *Coil and Plunger.*—A detached iron core is attracted into a hollow coil, or solenoid, of copper wire, when a current of electricity flows round the latter. This is a special form, and will receive extended consideration.

5. *Special Forms.*—Besides the leading forms enumerated above, there are a number of special types, multipolar, spiral, and others designed for particular purposes. There is also a group of forms intermediate between the ordinary electromagnet and the coil and plunger form.

POLARITY.

It is a familiar fact that the polarity of an electromagnet depends upon the sense in which the current is flowing around it. Various rules for remembering the relation of the electric flow and the magnetic force have been given. One of them that is useful is that when one is looking at the north pole of an electromagnet, the current will be flowing around that pole in the sense opposite to that in which the hands of a clock are seen to revolve. Another useful rule suggested by Maxwell is illustrated by Fig. 13, namely, that

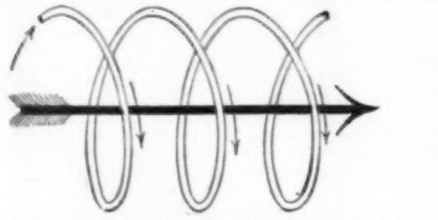


FIG. 13.—DIAGRAM ILLUSTRATING RELATION OF MAGNETIZING CIRCUIT AND RESULTING MAGNETIC FORCE.

the sense of the circulation of the current (whether right or left handed) and the positive direction of the resulting magnetic force are related together in the same way as the rotation and the travel of a right handed screw are associated together. Right handed rotation of the screw is associated with forward travel. Right handed circulation of a current is associated with a magnetic force tending to produce north polarity at the forward end of the core.

USES IN GENERAL.

Regarded as a piece of mechanism, an electromagnet may be regarded as an apparatus for producing a mechanical action at a place distant from the operator who controls it; the means of communication from the operator to the distant point where the electromagnet is being the electric wire. The uses of electromagnets may, however, be divided into two main divisions. For certain purposes an electromagnet is required merely for obtaining temporary adhesion or lifting power. It attaches itself to an armature, and cannot be detached so long as the exciting current is maintained, except by the application of a superior opposing pull. The force which an electromagnet thus exerts upon an armature of iron, with which it is in direct contact, is always considerably greater than the force with which it can act on an armature at some distance away, and the two cases must be carefully distinguished. *Traction* of an armature in contact, and *attraction* of an armature at a distance, are two different functions. So different, indeed, that it is no exaggeration to say that an electromagnet designed for the one purpose is unfitted for the other.

The question of designing electromagnets for either of these purposes will occupy a large part of these lectures. The action which an electromagnet exercises on an armature in its neighborhood may be of several kinds. If the armature is of soft iron, placed nearly parallel to the other polar surfaces, the action is one simply of attraction, producing a motion of pure translation, irrespective of the polarity of the magnet.

If the armature lies oblique to the line of the poles, there will be a tendency to turn it round, as well as to attract it. But, again, if the armature is of soft iron the action will be independent of the polarity of the magnet, that is to say, independent of the direction of the exciting current. If, however, the armature be itself a magnet of steel permanently magnetized, then the direction in which it tends to turn, and the amount or even the sign of the force with which it is attracted, will depend on the polarity of the electromagnet, that is to say, will depend on the direction in which the exciting current circulates. Hence there arises a difference between the operation of a *non-polarized* and that of a *polarized* apparatus, the latter term being applied to those forms in which there is employed a portion—say an armature—to which an initial fixed magnetization has been imparted. Non-polarized apparatus is in all cases independent of the direction of the current. Another class of uses served by electromagnets is the production of rapid vibrations.

These are employed in the mechanism of electric trembling bells, in the automatic breaks of induction coils, in electrically driven tuning forks such as are employed for chronographic purposes, and in the instruments used in harmonic telegraphy. Special constructions of electromagnet are appropriate to special purposes such as these. The adaptation of electromagnets for the special end of responding to rapidly alternating currents is a closely kindred matter. Lastly, there are certain applications of the electromagnet, notably in the construction of some forms of arc lamp, for which it is specially sought to obtain an equal, or approximately equal, pull over a definite range of motion. This use necessitates special designs.

THE PROPERTIES OF IRON.

A knowledge of the magnetic properties of iron of different kinds is absolutely fundamental to the theory and design of electromagnets. No excuse is therefore necessary for treating this matter with some fullness. In all modern treatises of magnetism the usual terms are defined and explained. Magnetism, which

* Lectures delivered before the Society of Arts, London, 1890. From the Journal of the Society.

was formerly treated of as though it were something distributed over the end surfaces of magnets, is now known to be a phenomenon of internal structure, and the appropriate mode of considering it is to treat the magnetic materials, iron and the like, as being capable of acting as good conductors of the magnetic lines, in other words, as possessing magnetic *permeability*. The precise notion now attached to this word is that of a numerical coefficient. Suppose a magnetic force—due, let us say, to the circulation of an electric current in a surrounding coil—were to act on a space occupied by air. There would result a certain number of magnetic lines in that space. In fact, the intensity of the magnetic force, symbolized by the letter H, is often expressed by saying that it would produce H magnetic lines per square centimeter in air. Now, owing to the superior magnetic power of iron, if the space subjected to this magnetic force were filled with iron instead of air, there would be produced a larger number of magnetic lines per square centimeter. This larger number in the iron expresses the degree of magnetization in the iron. It is symbolized* by the letter B. The ratio of B to H expresses the permeability of the material. The usual symbol for permeability is the Greek letter μ. So we may say that B is equal to μ times H. For example, a certain specimen of iron, when subjected to a magnetic force capable of creating, in air, 50 magnetic lines to the square centimeter, was found to be permeated by no fewer than 16,062 magnetic lines per square centimeter. Dividing the latter figure by the former gives as the value of the permeability of this stage of the magnetization 321, or the permeability of the iron is 321 times that of air. The permeability of such non-magnetic materials as silk, cotton, and other insulators, also of brass, copper, and all the non-magnetic metals, is taken as 1, being practically the same as that of the air.

This mode of expressing the facts is, however, complicated by the fact of the tendency in all kinds of iron to magnetic saturation. In all kinds of iron the magnetizability of the material becomes diminished as the actual magnetization is pushed further. In other words, when a piece of iron has been magnetized up to a certain degree it becomes, from that degree onward, less permeable to further magnetization, and, though actual saturation is never reached, there is a practical limit beyond which the magnetization cannot well be pushed.

Joule was one of the first to establish this tendency toward magnetic saturation. Modern researches have shown numerically how the permeability diminishes as the magnetization is pushed to higher stages. The practical limit of the magnetization, B, in good wrought iron is about 20,000 magnetic lines to the square centimeter, or about 125,000 lines to the square inch; and in cast iron the practical saturation limit is nearly 12,000 lines per square centimeter, or about 70,000 lines per square inch. In designing electromagnets, before calculations can be made as to the size of a piece of iron required for the core of a magnet for any particular purpose, it is necessary to know the magnetic properties of that piece of iron, for it is obvious that if the iron be of inferior magnetic permeability, a larger piece of it will be required in order to produce the same magnetic effect as might be produced with a smaller piece of higher permeability. Or, again, the piece having inferior permeability will require to have more copper wire wound on it. For in order to bring up its magnetization to the required point, it must be subjected to higher magnetizing forces than would be necessary if a piece of higher permeability had been selected.

A convenient mode of studying the magnetic facts respecting any particular brand of iron is to plot on a diagram the curve of magnetization—*i. e.*, the curve in which the values, plotted horizontally, represent the magnetic force, H, and the values plotted vertically those that correspond to the respective magnetization, B. In Fig. 14, which is modified from the researches of Professor Ewing, are given five curves relating to soft iron, hardened iron, annealed steel, hard drawn steel, and glass hard steel. It will be noticed that all these curves have the same general form. For small values of H the values of B are small, and as H is increased, B increases also. Further, the curve rises very suddenly, at least with all the softer sorts of iron, and then bends over and becomes nearly horizontal. When the magnetization is in the stage below the bend of the curve, the iron is said to be far from the state of saturation. But when the magnetization has been pushed beyond the bend of the curve, the iron is said to be in the stage approaching saturation, because at this stage of magnetization it requires a large increase in the magnetizing force to produce even a very small increase in the magnetization. It will be noted that for soft wrought iron the stage of approaching saturation sets in when B has attained the value of about 16,000 lines per square centimeter, or when H has been raised to the value of about 50. As we shall see, it is not economical to push B beyond this limit, or, in other words, it does not pay to use stronger magnetic forces than those of about H = 50.

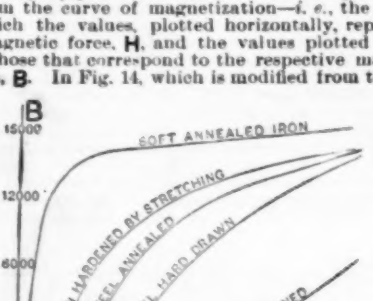


FIG. 14.—CURVES OF MAGNETIZATION OF DIFFERENT MAGNETIC MATERIALS.

METHODS OF MEASURING PERMEABILITY.

There are four sorts of experimental methods of measuring permeability.

1. *Magnetometric Methods.*—These are due to Muller, and consist in surrounding a bar of the iron in question by a magnetizing coil, and observing the deflection its magnetization produces in a magnetometer.

2. *Balance Methods.*—These methods are a variety of the preceding, a compensating magnet being employed to balance the effect produced by the magnetized iron on the magnetometric needle. Von Feilitzsch used this method, and it has received a more definite application in the magnetic balance of Professor Hughes. The actual balance is exhibited to-night upon the table, and I have beside me a large number of observations made by students of the Technical College by its means, upon sundry samples of iron and steel. None of these methods are, however, to be compared with those that follow.

3. *Inductive Methods.*—There are several varieties of these, but all depend on the generation of a transient induction current in an exploring coil which surrounds the specimen of iron, the integral current being proportional to the number of magnetic lines introduced into, or withdrawn from, the circuit of the exploring coil. Three varieties may be mentioned.

(*A*) *Ring Method.*—In this method, due to Kirchhoff, the iron under examination is made up into a ring, which is wound with a primary or exciting coil and with a secondary or exploring coil. Determinations on this plan have been made by Stowletow, Rowland, Bosanquet, and Ewing; also by Hopkinson. Rowland's arrangement of the experiment is shown in Fig. 15, in which B is the exciting battery; S, the switch for turning on or reversing the current; R, an adjustable resistance; A, an ampere-meter; and BG the ballistic galvanometer, the first swing of which measures the integral induced current. RC is an earth inductor or reversing coil wherewith to calibrate the readings of the galvanometer; and above is an arrangement of a coil and a magnet to assist in bringing the swinging needle to rest between the observations. The exciting coil and the exploring coil are both wound upon the ring; the former is distinguished by being drawn with a thicker line. The usual mode of procedure is to begin with a feeble exciting current, which is suddenly reversed, and then reversed back. The current is then increased, reversed, and re-reversed; and so on, until the strongest available points are reached. The values of the magnetizing force H are calculated from the observed value of the current by the following rule. If the strength of the current, as measured by the ampere-meter, be i, the number of spires of the exciting coil S, and the length, in centimeters, of the coil (*i. e.*, the mean circumference of the ring) be l, then H is given by the formula—

$$H = \frac{4\pi}{10} \times \frac{S\,i}{l} = 1{\cdot}2566 \times \frac{S\,i}{l}$$

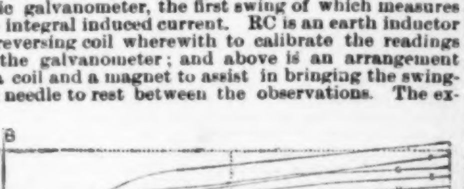


FIG. 15.—RING METHOD OF MEASURING PERMEABILITY (ROWLAND'S ARRANGEMENT).

Bosanquet, applying this method to a number of iron rings, obtained some important results. In Fig. 16 are plotted out the values of H and B for seven rings. One of these, marked J, was of cast steel, and was examined both when soft and afterward when hardened. Another, marked I, was of the best Lowmoor iron. Five were of Crown iron, of different sizes. They were marked for distinction with the letters G, E, F, H, K. In the accompanying table are set down the values of B at different stages of the magnetization.

TABLE OF VALUES OF B IN FIVE CROWN IRON RINGS.

Name.	G.	E.	F.	H.	K.
Mean Diam. / Bar thickness.	21·5 cm. / 2·535	10·035 cm. / 1·298	22·1 cm. / 1·291	10·735 cm. / 0·7133	22·725 cm. / 0·7544
Magnetising Force.					
0·2	126	73	62	82	85
0·5	377	270	224	208	214
1	1,449	1,293	840	675	885
2	4,564	3,952	3,533	2,777	2,417
5	9,900	9,147	8,293	8,479	8,884
10	13,023	13,357	12,540	11,376	10,333
20	14,911	14,653	14,710	14,066	13,273
50	16,217	15,704	16,062	15,174	13,890
100	17,148	16,677	17,900	16,134	14,837

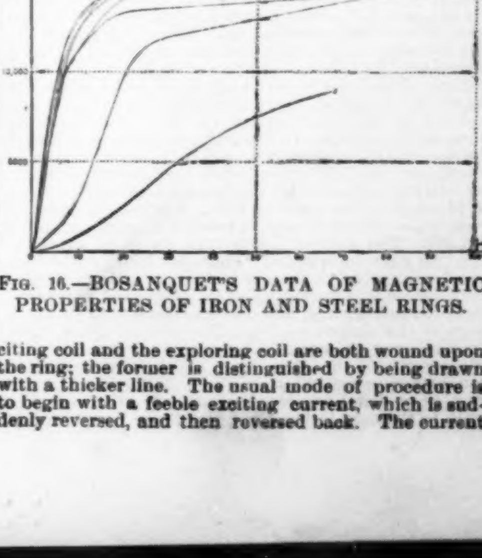


FIG. 16.—BOSANQUET'S DATA OF MAGNETIC PROPERTIES OF IRON AND STEEL RINGS.

I have the means here of illustrating the induction method of measuring permeability. Here is an iron ring, having a cross section of almost exactly one square centimeter. It is wound with an exciting coil supplied with current by two accumulator cells; over it is also wound an exploring coil of 100 turns connected in circuit (as in Rowland's arrangement) with a ballistic galvanometer which reflects a spot of light upon yonder screen. In the circuit of the galvanometer is also included a reversing earth coil. As a matter of fact this earth coil is of such a size, and wound with so many convolutions of wire, that when it is turned over the amount of cutting of magnetic lines is equal to 840,000, or is the same as if 840,000 magnetic lines had been cut once. By adjusting the resistance of the galvanometer circuit, it is arranged that the first swing due to the induced current when I suddenly turn over the earth coil is 8·4 scale divisions. Then, seeing that our exploring coil has 100 turns, it follows that when in our subsequent experiment with the ring we get an induced current from it, each division of the scale over which the spot swings will mean 1,000 lines in the iron. I turn on my exciting current. See: it swings about 11 divisions. On breaking the circuit it swings nearly 11 divisions the other way. That means that the magnetizing force carries the magnetization of the iron up to 11,000 lines'; or, as the cross section is about 1 square centimeter, B = 11,000. Now, how much is H? The exciting coil has 180 windings, and the exciting current through the amperemeter is just one ampere. The total excitation is just 180 "ampere-turns." We must, according to our rule given above, multiply this by 1·2566 and divide by the mean circumferential length of the coil, which is about 32 centimeters. This makes H = 7. So if B = 11,000 and H = 7, the permeability (which is the ratio of them) is about 1,570. It is a rough and hasty experiment, but it illustrates the method.

Bosanquet's experiments settle the debated question whether the outer layers of an iron core shield the inner layers from the influence of magnetizing forces. Were this the case, the rings made from thin bar iron should exhibit higher values of B than do the thicker rings. This is not so; for the thickest ring, G, shows throughout the highest magnetizations.

(*B*) *Bar Method.*—This method consists in employing a long bar of iron instead of a ring. It is covered from end to end with the exciting coil, but the exploring coil consists of but a few turns of wire situated just over the middle part of the bar. Rowland, Bosanquet, and Ewing have all employed this variety of method; and Ewing specially used bars the length of which was more than 100 times their diameter, in order to get rid of errors arising from end effects.

(*C*) *Divided Bar Method.*—This method, due to Dr. Hopkinson,* is illustrated by Fig. 17.

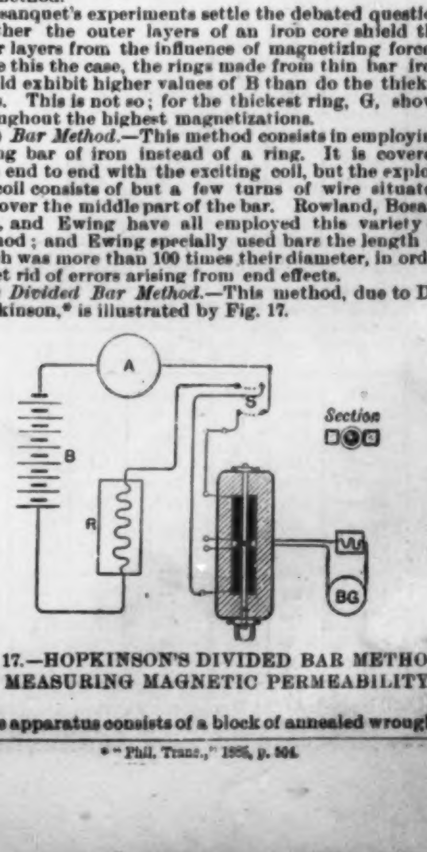


FIG. 17.—HOPKINSON'S DIVIDED BAR METHOD OF MEASURING MAGNETIC PERMEABILITY.

The apparatus consists of a block of annealed wrought

* The following are the various ways of expressing the three quantities under consideration:

B—The internal magetization.
The magnetic induction.
The induction.
The intensity of the induction.
The permeation.
The number of lines per square centimeter in the material.

H—The magnetizing force at a point.
The magnetic force at a point.
The intensity of the magnetic force.
The number of lines per square centimeter that there would be in air.

μ—The magnetic permeability.
The permeability.
The specific conductivity for magnetic lines.
The magnetic multiplying power of the material.

* "Phil. Trans.," 1885, p. 504.

iron about 18 inches long, 6½ wide, 2 deep, out of the middle of which is cut out a rectangular space to receive the magnetizing coils.

The test samples of iron consist of two rods, each 12·65 millimeters in diameter, turned carefully true, and slide in through holes bored in the end of the iron blocks. These two rods meet in the middle, their ends being faced true so as to make a good contact. One of them is secured firmly, and the other has a handle fixed to it, by means of which it can be withdrawn. The two large magnetizing coils do not meet, a space being left between them. Into this space is introduced the little exploring coil, wound upon an ivory bobbin, through the eye of which passes the end of the movable rod. The exploring coil is connected to the ballistic galvanometer, BG, and is attached to an India rubber spring (not shown in the figure), which, when the rod is suddenly pulled back, causes it to leap entirely out of the magnetic field. The exploring coil had 350 turns of fine wire; the two magnetizing coils had 2,008 effective turns. The magnetizing current, generated by a battery, B, of eight Grove cells, was regulated by a variable liquid resistance, R, and by a shunt resistance. A reversing switch and an amperemeter, A, were included in the magnetizing circuit. By means of this apparatus the sample rods to be experimented upon could be submitted to any magnetizing forces, small or large, and the actual magnetic condition could be examined at any time by breaking the circuit and simultaneously withdrawing the movable rod. This apparatus, therefore, permitted the observation separately of a series of increasing (or decreasing) magnetizations without any intermediate reversals of the entire current. Thirty-five samples of various irons of known chemical composition were examined by Hopkinson, the two most important for present purposes being an annealed wrought iron and a gray cast iron, such as are used by Messrs. Mather & Platt in the construction of dynamo machines. Hopkinson embodied his results in curves, from which it is possible to construct, for purposes of reference, numerical tables of sufficient accuracy to serve for future calculations. The curves of these two samples of iron are reproduced in Fig. 18, but with one simple modification. British engineers, who unfortunately are condemned by local circumstances to use inch measures instead of the international metric system, prefer to have the magnetic facts also stated in terms of square inch units instead of square centimeter units. This change has been made in Fig. 18, and the symbols $B_{''}$ and $H_{''}$ are chosen to

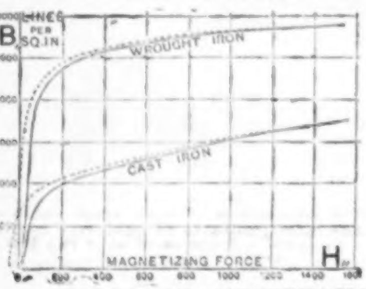


FIG. 18.—CURVES OF MAGNETIZATION OF IRON.

indicate the numbers of magnetic lines to the square inch in iron and in air respectively. The permeability or multiplying power of the iron is the same, of course, in either measure. In Table II. are given the corresponding data in square inch measure; and in Table III. the data is in square centimeter measure for the same specimens of iron.

TABLE II. (SQUARE INCH UNITS.)

Annealed Wrought Iron.			Grey Cast Iron.		
$B_{''}$	μ	$H_{''}$	$B_{''}$	μ	$H_{''}$
30,000	4,650	6·5	25,000	763	32·7
40,000	3,877	10·3	30,000	756	39·7
50,000	3,031	16·5	40,000	258	155
60,000	2,150	27·8	50,000	114	439
70,000	1,921	36·4	60,000	74	807
80,000	1,400	50·8	70,000	48	1480
90,000	907	99·2	—	—	—
100,000	408	245	—	—	—
110,000	166	664	—	—	—
120,000	76	1581	—	—	—
130,000	35	3714	—	—	—
140,000	27	5185	—	—	—

TABLE III. (SQUARE CENTIMETER UNITS.

Annealed Wrought Iron.			Grey Cast Iron.		
B	μ	H	B	μ	H
5,000	3,000	1·66	4,000	800	5
9,000	2,250	4	5,000	500	10
10,000	2,000	5	6,000	279	21·5
11,000	1,692	6·5	7,000	133	42
12,000	1,412	8·5	8,000	100	80
13,000	1,083	12	9,000	71	127
14,000	823	17	10,000	53	188
15,000	526	28·5	11,000	37	292
16,000	320	50	—	—	—
17,000	161	105	—	—	—
18,000	90	200	—	—	—
19,000	54	350	—	—	—
20,000	30	666	—	—	—

It will be noted that Hopkinson's curves are double, there being one curve to the ascending magnetizations, and a separate one, a little above the former, for descending magnetizations. This is a point of a little importance in designing electromagnets. Iron, and particularly hard sorts of iron, and steel, after having been subjected to a high degree of magnetizing force, and subsequently to a lesser magnetizing force, are found to retain a higher degree of magnetization than if the lower magnetizing force had been simply applied. For example, reference to Fig. 18 shows that the wrought iron, where subjected to a magnetizing force gradually rising from zero to $H_{''} = 200$, exhibits a magnetization of $B_{''} = 95,000$; but after $H_{''}$ has been carried up to over 1,000, and then reduced again to 200, $B_{''}$ does not come down again to 95,000, but only to 98,000. Any sample of iron which showed great retentive qualities, or in which the descending curve differs widely from the ascending curve, would be unsuitable for constructing electromagnets, for it is important that there should be as little residual magnetism as possible in the cores. It will be noted that the curves for cast iron show more of this residual effect than do those for wrought iron. The numerical data in Tables II. and III. are means between the ascending and descending values.

As an example of the use of the tables, we may take the following: How strong must the magnetizing force be in order to produce in wrought iron a magnetization of 110,000 lines to the square inch? Reference to Table II., or to Fig. 18, shows that a magnetizing field of 664 will be required, and that at this stage of the magnetization the permeability of the iron is only 166. As there are 6·45 square centimeters to the square inch, 110,000 lines to the square inch correspond very nearly to 17,000 lines to the square centimeter; and $H_{''} = 664$ corresponds very nearly to $H = 100$.

TRACTION METHODS.

Another group of methods of measuring permeability is based upon the law of magnetic traction. Of these there are several varieties.

(*D*) *Divided Ring Method.*—Mr. Shelford Bidwell has kindly lent me the apparatus with which he carried out this method. It consists of a ring of very soft charcoal iron rod 6·4 millimeters in thickness, the external diameter being 8 centimeters, sawn into two half rings, and then each half carefully wound over with an exciting coil of insulated copper wire of 1,929 convolutions in total. The two halves fit neatly together; and in this position it constitutes practically a continuous ring. When an exciting current is passed round the coils, both halves become magnetized and attract one another. The force required to pull them asunder is then measured. According to the law of traction, which will occupy us in the second lecture, the tractive force (over a given area of contact) is proportional to the square of the number of magnetic lines that pass from one surface to the other through the contact joint. Hence the force of traction may be used to determine B; and on calculating H as before, we can determine the permeability. The following Table IV. gives a summary of Mr. Bidwell's results.

TABLE IV. (SQUARE CENTIMETER MEASURE.)

Soft Charcoal Iron.		
B	μ	H
7,390	1830·7	3·9
11,550	1121·4	10·3
15,460	386·4	40
17,330	150·7	115
18,470	88·8	208
19,330	45·3	427
19,820	33·9	585

(*E*) *Divided Rod Method.*—In this method, also used by Mr. Bidwell, an iron rod hooked at both ends was divided across the middle, and placed within a vertical surrounding magnetizing coil. One hook was hung up to an overhead support; to the lower hook was hung a scale pan. Currents of gradually increasing strength were sent around the magnetizing coil from a battery of cells and note was taken of the greatest weight which could in each case be placed in the scale pan without tearing asunder the ends of the rods.

(*F*) *Permeameter Method.*—This is a method which I have myself devised for the purpose of testing specimens of iron. It is essentially a workshop method, as distinguished from a laboratory method. It requires no ballistic galvanometer, and the iron does not need to be forged into a ring or wound with a coil. For carrying it out a simple instrument is needed, which I venture to denominate as a *permeameter*. Outwardly, it has a general resemblance to Dr. Hopkinson's apparatus, and consists, as you see (Fig. 19), of a rectangular piece of soft wrought iron, slotted out to receive a magnetizing coil, down the axis of which passes a brass tube. The block is 12 in. long, 6½ in. wide, and 3 in. in thickness. At one end the block is bored to receive the sample of iron that is to be tested. This consists simply of a thin rod about a foot long, one end of which must be carefully surfaced up. When it is placed inside the magnetizing coil, and the exciting current is turned on, the rod sticks tightly at its lower end to the surface of the iron block; and the force required to detach it (or, rather, the square root of that force) is a measure of the permeation of the magnetic lines through its end face. In the first permeameter which I constructed the magnetizing coil is 13·64 centimeters in length, and has 371 turns of wire. One ampere of exciting current consequently produces a magnetizing force of $H = 34$. The wire is thick enough to carry 30 amperes, so that it is easy to reach a magnetizing force of 1,000. The current I now turn on is 25 amperes. The two rods here are of "charcoal iron" and "best iron" respectively; they are of quarter inch square stuff. Here is a spring balance graduated carefully, and provided with an automatic catch so that its index stops at the highest reading. The tractive force of the charcoal iron is about 12½ lb., while that of the "best" iron is only 7¼ lb. B is about 19,000 in the charcoal iron, and H being 850, μ is about 22·3. The law of traction which I use in calculating B will occupy us much in the next lecture, but meantime I content myself in stating it here for use with the permeameter. The formula for calculating B when the core is thus detached by a pull of P pounds, the area of contact being A square inches, is as follows:

$$B = 1{,}317 \times \sqrt{P \div A} + H$$

I may add that the instrument, in its final form, is

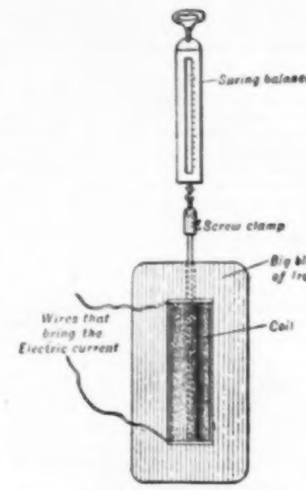


FIG. 19.—THE PERMEAMETER.

manufactured from my designs by Messrs. Nalder Bros., the well known makers of so many electrical instruments.

CURVES OF MAGNETIZATION AND PERMEABILITY.

In reviewing the results obtained, it will be noted that the curves of magnetization all possess the same general features, all tending toward a practical maximum, which, however, is different for different materials. Joule expressed the opinion that "no force of current could give an attraction equal to 200 lb. per square inch," the greatest he actually attained being only 175 lb. per square inch. Rowland was of opinion the limit was about 177 lb. per square inch for an ordinary good quality of iron, even with infinitely great exciting power. This would correspond roughly to a limiting value of B of about 17,500 lines to the square centimeter. This value has, however, been often surpassed. Bidwell obtained 19,820, or possibly a trifle more, as in Bidwell's calculation the value of H has been needlessly discounted. Hopkinson gives 18,250 for wrought iron, and 19,840 for mild Whitworth steel. Kapp gives 16,740 for wrought iron, 20,460 for charcoal iron in sheet, and 25,250 for charcoal iron in wire. Bosanquet found the highest value in the middle bit of a long bar to run up in one specimen to 21,428, in another to 29,388, in a third to 27,688. Ewing, working with extraordinary magnetic power, forced up the value of B in Lowmoor iron to 31,560 (when μ came down to 3), and subsequently to 45,350. This last figure corresponds to a traction exceeding 1,000 pounds to the square inch.

Cast iron falls far below these figures. Hopkinson, using a magnetizing force of 240, found the values of B to be 10,783 in gray cast iron, 12,408 in malleable cast iron, and 10,546 in mottled cast iron. Ewing, with a magnetizing force nearly fifty times as great, forced up the value of B in cast iron to 31,760. Mitis metal, which is a sort of cast wrought iron, being a wrought iron rendered fluid by addition of a small percentage of aluminum, is, as I have found, more magnetizable than cast iron, and not far inferior to wrought iron. It should form an excellent material for the cores of electromagnets for many purposes where a cheap manufacture is wanted.

A very useful alternative mode of studying the results obtained by experiment is to construct curves, such as those of Fig. 20, in which the values of the

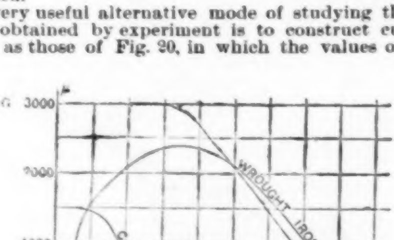


FIG. 20.—CURVES OF PERMEABILITY.

permeability are plotted out vertically in correspondence with the values of B plotted horizontally. It will be noticed that in the case of Hopkinson's specimen of annealed wrought iron, between the points where $B = 7,000$ and $B = 16,000$, the mean values of μ lie almost on a straight line, and might be approximately calculated from the equation:

$$\mu = (17{,}000 - B) \div 3{\cdot}5$$

THE LAW OF THE ELECTROMAGNET.

Many attempts have been made, by Muller, Lamont, Frolich, and others, to discover a simple algebraic formula whereby to express the relation between the magnetizing force and the magnetism produced in the electromagnet. According to Muller, these are related to one another in the same proportions as the natural tangent is related to the arc which it subtends. The formulæ of Lamont and Frolich, which are more nearly in keeping with the facts, are based upon the assumption of a relation between the permeability and the degree of magnetization present. Suppose we assume the approximation stated above, that the permeability is proportional to the difference between B and some higher

limiting value (17,000 for wrought iron, 7,000 for cast iron). If this higher value is called β, we may write

$$\mu = \frac{\beta - \mathsf{B}}{a}$$

where a is a constant that varies with the quality of the iron or steel.

Now

$$\mathsf{B} = \mu \mathsf{H}$$

giving by substitution and an easy transformation—

$$\mathsf{B} = \beta \frac{\mathsf{H}}{a + \mathsf{H}}$$

which is one form of Frolich's well-known formula. The constant, a, stands for the "diacritical" value of the magnetizing force, or that value which will bring up B to half the assumed limiting or "satural" value.

All such formulæ, however convenient, are insufficient, inasmuch as they fail to take into account the properties of the entire magnetic circuit.

HYSTERESIS.

I have already drawn attention to the difference between the ascending and descending curves of magnetization, and may now point out that this is a part of a set of general phenomena of residual effects. The best known of these effects is, of course, the existence in some kinds of iron, and notably in steel, of a remanent or sub-permanent magnetization after the magnetizing force has been entirely removed. To this retardation of effects behind the causes that produce them the name of "hysteresis" has been given by Prof. Ewing. If a piece of iron is subjected to a magnetizing force which increases to a maximum, then is decreased down to zero, then reversed and carried to a negative maximum, then decreased again to zero, and so carried round an entire cycle of magnetic operations, it is observed that the curves of magnetization form a closed area similar in general to those shown in Fig. 21.

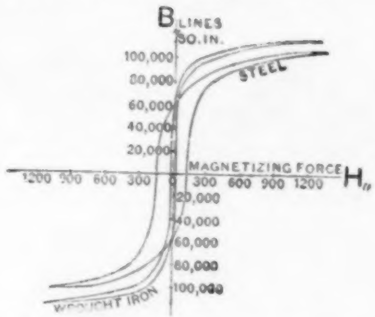


FIG. 21.—CURVES OF HYSTERESIS.

This closed area represents the work which has been wasted or dissipated in subjecting the iron to these alternate magnetizing forces. In very soft iron, where the ascending and descending curves are close together, the inclosed area is small; and as a matter of fact, very little energy is dissipated in a cycle of magnetic operations. On the other hand, with hard iron, and particularly with steel, there is a great width between the curves, and there is a great waste of energy. Hysteresis may be regarded as a sort of internal or molecular magnetic friction, by reason of which alternate magnetizations cause the iron to grow hot. Hence the importance of understanding this curious effect, in view of the construction of electromagnets that are to be used with rapidly alternating currents. The following figures of Table V. give the number of watts (1 watt = $\frac{1}{746}$ of a horse power) wasted by hysteresis in well-laminated soft wrought iron when subjected to a succession of rapid cycles of magnetization.

TABLE V.—WASTE OF POWER BY HYSTERESIS

B	B	Watts wasted per cubic foot at 10 cycles per second.	Watts wasted per cubic foot at 100 cycles per second.
4,000	25,800	40	400
5,000	32,250	57·5	575
6,000	38,700	75	750
7,000	45,150	93·5	935
8,000	51,600	111	1,110
10,000	64,500	156	1,560
12,000	77,400	206	2,060
14,000	90,300	260	2,600
16,000	103,200	324	3,240
17,000	109,650	394	3,940
18,000	116,100	487	4,870

It will be noted that the waste of energy increases as the magnetization is pushed higher and higher in a disproportionate degree, the waste when B is 18,000 being six times that when B is 6,000. In the case of hard iron or of steel the heat waste would be far greater.

Another kind of after-effect was discovered by Ewing, and named by him "viscous hysteresis." This is the name given to the gradual creeping up of the magnetization when a magnetic force is applied with absolute steadiness to a piece of iron. This gradual creeping up may go on for half an hour or more, and amount to several per cent. of the total magnetization.

Another important matter is that all such actions as hammering, rolling, twisting, and the like, impair the magnetic quality of annealed soft iron. Annealed wrought iron which has never been touched by a tool shows hardly any trace of residual magnetization, even after the application of magnetic forces. But the touch of the file will at once spoil it. Sturgeon pointed out the great importance of this point. In the specification for tenders for instruments for the British postal telegraphs it is laid down as a condition to be observed by the constructor that the cores must not be filed after being annealed. The continual hammering of the armature of an electromagnet against the poles may in time produce a similar effect.

FALLACIES AND FACTS ABOUT ELECTROMAGNETS.

I will conclude this lecture by stating a few of the fallacies that are current about electromagnets, and will add to them a few facts, some of which seem paradoxical. The refutation of the fallacies and the explanation of the facts will come in due course.

Fallacies.—The attraction of an electromagnet for its armature varies inversely as the square of its distance from the poles.

The outer windings of the electromagnet are necessarily less effective than those that are close to the iron.

Hollow iron cores are as good as solid cores of the same size.

Pole pieces add to the lifting power of an electromagnet.

It hurts an electromagnet (or, for that matter, a steel magnet) to pull off the keeper suddenly. [It is the sudden slamming on that in reality hurts it.]

The resistance of the coil of an electromagnet ought to be equal to the resistance of the battery.

A coil wound left-handedly magnetizes a magnet differently from a coil wound right-handedly. [It is not a question of winding of coil, but of circulation of current.]

Thick wire electromagnets are less powerful than thin wire electromagnets.

A badly insulated electromagnet is more powerful than one that is well insulated.

A square iron core is less powerful (as Dal Negro says, eighteenfold!) than a round core of equal weight.

The attraction of an electromagnet for its keeper is necessarily less strong (one-third according to Du Moncel) sideways than when the keeper is in front of the poles.

Putting a tube of iron outside the coils of an electromagnet makes it attract a distant armature more powerfully.

Facts.—A bar electromagnet with a convex pole holds on tighter to a flat-ended armature than one with a flat pole does.

A thin round disk of iron laid upon the flat round end of an electromagnet (the pole end being slightly larger than the disk) the disk is not attracted, and will not stick on, even if laid down quite centrally.

If a flat armature of iron be presented to the poles of a horseshoe electromagnet, the attraction at a short distance is greater, if the armature is presented flankways than if it is presented edgeways. On the contrary, the tractive force in contact is greater edgeways than flankways.

Electromagnets with long limbs are practically no better than those with short limbs for sticking on to masses of iron.

PARKHURST'S ELECTRIC MOTOR.

To the Editor of the Scientific American:

Referring to the comments of Dr. A. P. Reid, of Halifax, upon the motor described in SUPPLEMENT, No. 761, I would say that doubtless the motor might be improved by making the field magnet of six bobbins instead of two; but in so doing the style of pole pieces would probably have to be changed to correspond to the changed conditions, entailing more work and greater skill in the manufacture, and also requiring more elaborate tools, lathe, etc., to aid in its manufacture.

The motor as illustrated and described was designed to be as simple as possible, and yet be powerful enough to do the intended work, *i. e.*, run a sewing machine. At the time it was built the possibility of making it more elaborate was seen, even beyond the suggestions already received; but these elaborations were not gone into, for the reason that they made the motor more complicated, and hence placed it beyond the skill of the tyro or the average amateur with but a limited supply of tools.

There can, however, be no objection to any one making as elaborate a model as they please—if the model described is not enough to satisfy. More iron can be put in the field magnet if desired, with probably beneficial results, and, if one chooses, a double armature and double field magnets, with two or more bobbins in each, may be made; but the double armature and double field would require two commutators and two sets of brushes, and hence, as above stated, such elaborations were not gone into.

For a field with six bobbins the pole pieces should preferably be in the form of a flat iron ring cut into two parts, so as to form a flat curved pole piece to each three of the six bobbins of the field, and the winding and connections should be so as to make these curved pole pieces the consequent poles of the entire system.

The pole pieces for the armature could then be a flat curved ring, continuous throughout, of the same size and thickness as the pole pieces of the field, fastened to the ends of the bobbin cores, or a flat iron disk could be used for such pole pieces, the line of polarity of the ring or disk being determined by the position of the brushes upon the commutator.

I did not put the details of the shunt into the original drawings, as I supposed it would be readily understood from the numerous articles that have gone before. The connections are made, however, by bringing the wires from the field magnet down through the bars of the motor, and, in grooves cut out for the purpose, to the armature end of the base, where they pass up again through holes in the base, and are then fastened to the brush arms permanently, after first being coiled into a long spiral to make the connections flexible. With this connection the current is applied directly to the binding posts upon the brush arms, and the binding posts upon the base are not needed.

If it is desired to use the binding posts upon the base, then the wires from the field magnets are led to them under the base and fastened permanently. Wires are then taken from these binding posts up through holes near the brush holder, and coiled up and fastened permanently to the brush arms. The current can then be applied to the binding screws upon the base, or to the brush holder binding posts at will.

If the field is wound with coarser wire, then it would probably not run well as a shunt motor, but would have to be connected up in series, *one* wire from the field magnet going to one of the binding posts upon the base, the other field magnet wire to one of the brush arms. The other brush arm then to be connected to the other binding post upon the base. The current would then be applied to the binding posts. A trial or two would soon tell which wire to connect to binding post, and which to brush holder, and to the proper arm thereof, in order to have the motor run in the desired direction. No experiments have ever been made as to the winding but to use as a generator, hence no detail can be given. It is doubtful if a very successful generator could be made of a size as given for the motor.

As stated above, the motor was designed as a simple, easily made and fairly efficient machine, well within the compass of ordinary tools and skill. It was not intended to be the *best* that could be made, even upon the same plan, for many improvements are possible. But such improvements involve more cost, more work, more skill, and I for one would be glad to see as many improvements and as much elaboration put upon the model as any one may choose to give it.

C. D. PARKHURST, Lieut., 4th Artillery.

ELECTRICAL STORMS ON PIKE'S PEAK.

THE "Annals of the Astronomical Observatory of Harvard College," vol. xxii., contains the meteorological observations made at the summit of Pike's Peak, Colorado, at a height of 14,134 feet above sea level. It is not remarkable that such an elevated station should be celebrated for its electrical storms, and the observers from 1874 to 1888 have recorded many interesting details in the journals respecting their physical and physiological actions.

The manifestation of atmospheric electricity by induced effects is often very strongly marked. During the passage of electrified clouds over the summit of the peak the well known singing and buzzing noises described as an adjunct of St. Elmo's fire were heard to proceed from the telegraph wires, the exposed instruments, the instrument shelter, and the house. The sound is said to be very similar to the buzzing of bees and crackling of burning evergreens. At times the hair of the observers became upright and strongly repellent, and the same peculiar noise proceeded from it.

Some very remarkable effects are recorded on August 18, 1877: "During the evening the most curiously beautiful phenomena ever seen by the observer were witnessed, in company with the assistant and four visitors. Mention has been made in journal of May 25 and July 13 of a peculiar 'singing' or rather 'sizzing' noise on the wire, but on these occasions it occurred in the day time. To-night it was heard again, but the line for an eighth of a mile was distinctly outlined in brilliant light, which was thrown out from the wire in beautiful scintillations. Near us we could observe these little jets of flame very plainly. They were invariably in the shape of a quadrant, and the rays concentrated at the surface of the line in a small mass about the size of a currant, which had a bluish tinge. These little quadrants of light were constantly jumping from one point to another of the line—now pointing in one direction, and again in another. There was no heat to the light, and when the wire was touched, only the slightest tingling sensation was felt. Not only was the wire outlined in this manner, but every exposed metallic point and surface was similarly tipped or covered. The anemometer cups appeared as four balls of fire revolving slowly round a common center; the wind vane was outlined with the same phosphorescent light, and one of the visitors was very much alarmed by sparks which were plainly visible in his hair, though none appeared in the others'. At the time of the phenomenon snow was falling, and it has been previously noticed that the 'singing' noise is never heard except when the atmosphere is very damp, and rain, hail, or snow is falling."

These displays were described with the same minuteness on June 7, 1882. It was then noticed that when the finger was passed along the line, the little jets of flame were successively puffed out, to be instantly relighted in the rear. An observer also found that when he approached one of the places from which the buzzing sound proceeded it would cease, but would recommence again as soon as he withdrew two or three feet distant.

It is recorded that the "observer, on placing his hands close over the revolving cups of the anemometer where the electrical excitement was abundant, did not discover the slightest sensation of heat, but his hands instantly became aflame. On raising them and spreading his fingers, each of them became tipped with one or more cones of light nearly three inches in length. The flames issued from his fingers with a rushing noise, similar to that produced by blowing briskly against the end of the finger when placed lightly against the lips, and accompanied by a crackling sound. There was a feeling as of a current of vapor escaping, with a slight tingling sensation. The wristband of his woolen shirt, as soon as it became dampened, formed a fiery ring around his arm, while his mustache was electrified so as to make a veritable lantern of his face. The phenomenon was preceded by lightning and thunder, and was accompanied by a dense driving snow, and disappeared with the cessation of snow."

A few instances are given of convulsive muscular contraction caused by discharges. Thus, on June 23, 1887, while an observer was examining the iron joints around the station, from which the above described hissing noise was proceeding, a strong electrical manifestation was felt by a twitching of the muscles of the face and hands. A violent "return shock" was experienced by the observer, who, on June 16, 1876, "while sitting on a rock, saw a blinding flash of lightning dart from a cloud seemingly not more than five hundred feet away, and heard a quick, deafening report, and at the same time received a shock that jerked his extremities together as though by a most violent convulsion, and left lightning sensations in them for a quarter of an hour afterward."

Among other effects previously noticed at considerable elevations above sea level we find that on one occasion an observer felt a pain as if from a slight burn on both temples directly under the brass buttons of his cap; when he put his hands to the spots, there was a sharp crack, and all pain disappeared. A peculiar burning sensation was also often felt on the face and

hands, and the scalp appeared to be pricked with hundreds of red hot needles. A more intense action is recorded on June 9, 1882, when an observer was "raised off his feet by the action of the electricity passing through the top of his hat. Instantly snatching the hat from his head, he observed a beam of light as thick as a lead pencil, which seemed to pass through the hat, projecting about an inch on either side and remaining visible for several seconds. The top of his hat was at least two inches from his head when this fiery lance pierced him. . . . He experienced a peculiar burning or stinging sensation of the scalp for several hours afterward."

The telegraph wires and the buildings were struck by lightning on several occasions. When a flash struck the telegraph wire on July 19, 1884, for a moment the line resembled a belt of fire, and vibrated violently for some minutes after the discharge. Frequent discharges have also been observed between the ground wire and the rocks on which it rested.

On August 12, 1879, it is recorded: "At 5.40 p. m. a bolt of lightning went through the arrester with the report of a rifle, throwing a ball of fire across the room against the stove and tin sheathing. At 6.35 p. m. the lightning struck the wire and building at the north end where the wires come through the window and arrester, with a crash equal to any forty-pounder. It burned every one of the four wires coming in at the window into small pieces, throwing them with great force in every direction, and filled the room with smoke from the burning gutta percha insulation. The window sash was splintered on the outside, one pane of glass broken, and another coated with melted copper. The anemometer wires were also burned up, and the dial burned and blown to pieces." Barometer bulbs were cracked by lightning on August 21, 1881; and on August 15, 1886, it is recorded: "Station struck by lightning at 6.45 p. m.; shattered the west window of the dining room, breaking four panes of glass and shivering the casing, leaving an opening between the casing and the wall; also slightly damaged the building in several places, and set fire to some articles in the storehouse, and burned several holes in the side of a tin bucket, allowing the water in it to escape."

Again, on September 7, 1888, we read: "Lightning struck the anemometer cups, burning a round hole about half an inch in diameter in one of them. The contact spring in the dial was badly bent, and the point of contact was considerably damaged by melting. When the insulated wire passed over a nail in the side of the house, the head of the nail was melted and the wire burned off. Inside the window, at a bend in the wire, electricity passed off into the sill, setting some paper on fire. The paper covering the battery box was ignited. Three window lights were broken. A tourist in the dining room was badly stunned. Observer in passing from dining room to office was severely stunned by what seemed and felt like a blow on the head. One hand swelled rather badly. The report in the house was double, and sounded like striking red hot iron upon which cold water had just been thrown."

Some interesting observations of hail stones are also given. The stones are said to vary in size from peas to pigeons' eggs, and many of them were conical in shape. Sometimes they consisted of soft white snow throughout, without any nucleus, and at other times they were so hard as to require a heavy blow to break them. When this was the case, the broken hail stones presented a stratified structure, with a center of clear ice, and concentric rings of solid and spongy ice, with an outer covering of soft snow. It is noted that in all hail storms the fall of hail entirely ceased for about half a minute following a heavy electric discharge; after this interval, however, the fall was considerably heavier than before.

The following observations, made on October 12, 1877, have an important bearing on the subject of hail formation: "The rotatory movement of the hail cloud could be plainly seen, and with every violent flash of lightning the passing cloud would grow perceptibly darker, indicating increased condensation. The hail formed by this cloud must have fallen about three miles below, for the wood packers reported quite solid hail at the timber line, and none above. This verifies the theory that a hail cloud can be transported laterally several miles while the ice stones are forming."

The constant crackling of hail when it reaches the earth is also referred to, and rocks are said to give forth a peculiar chattering noise, as if they were shaken by subterranean convulsions, during the occurrence of heavy hail storms.

These instances of inductive actions manifested during thunder storms, electrical discharges, and their relation to hail storms might be considerably multiplied. They confirm previous observations in an intense manner, and should be of some assistance to the student of meteorological phenomena.—*R. A. Gregory, in Nature.*

CONCERNING SPIDERS.*

It would seem as if the spider ought to be well enough known to everybody to make it unnecessary to describe it; but, although it is very widely distributed, a close examination is rarely made of this little animal. Some persons are restrained by a fear that is not justified, and others by an unconquerable repugnance. There are details, however, that can be seen only by means of a lens and with strict attention. We shall therefore recall in a few words the peculiarities of its structure and organization.

The body of the spider is composed of two very distinct parts—one comprising the head and thorax together (cephalothorax), and the other the abdomen—sharply defined by a constriction. On the front of the head there are two appendages provided with venomous hooks, and upon the top are distributed the eyes to the number of six or eight (in most cases eight). The domestic spider (*Tegenaria*) has eight, arranged in two parallel rows (four to the row), forming two nearly straight lines.

Everything is strange in the eyes of this animal—the number, the arrangement, and the diversity in size and form, that does not necessarily imply a very extended or delicate or very sharp sight.

In the first place, the eyes are fixed and do not roll in their orbits as ours do, to allow the animal to direct them toward the various points of space. Is not the large number designed to make up for the want of mobility? Instead of a single eye that moves in its orbit and accommodates itself to various distances, these are perhaps fixed eyes that have each a particular direction and that permit the animal to see at varied distances. Again, who knows whether some of them are not used

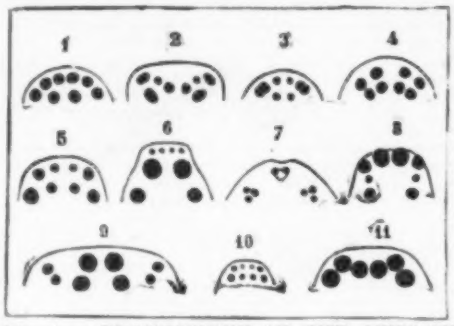


Fig. 1.—ARRANGEMENT OF THE EYES IN VARIOUS SPECIES OF SPIDERS.

1. Argyroneta. 2. Cteniza. 3. Theridion. 4. Agelena. 5. Thomisa. 6. Lycosa. 7. A species allied to spiders. 8. Saltica. 9. Epeira. 10. Tetragnatha. 11. Segestria.

in darkness and others in daylight? This is a study to be undertaken by placing the animals in conditions that permit of the use of only certain of its eyes by turns.

Spiders are diurnal or nocturnal, and there are some that live underground, and this requires eyes in harmony with these various conditions of existence. The family *Theridiidæ*, the male possesses a stridulatory organ, and this allows of the supposition that hearing exists in the female of this family.

Spiders, as we know, have eight legs, but what we did not know previous to the ingenious experiments of Mr. Carlet was how they walked. The learned professor of Grenoble made a comparative study of the walk of four, six, and eight footed animals. Among quadrupeds, for example, the giraffe ambles, that is to say, alternately advances the two legs of the same side, while the horse has two gaits, for it can amble or alternately advance one of the fore legs with the hind one of the opposite side. The movement of lizards, frogs, and turtles in no wise resembles that of the quadruped mammals, despite the fact that they have the same number of limbs.

Insects simultaneously and alternately advance the odd legs of the same side (first and third) with the even leg (second) of the opposite, while they are resting upon the three others. The three points of support are the apices of a triangle. They walk like two quadrupeds that would have the two middle legs in common, one possessing the four first, and the other the four last.

Finally, spiders walk like two quadrupeds in a line with one another, that is to say, by advancing the legs of uneven number (one and three) on one side, and, at the same time, those of even number (two and four) on the opposite side. If we suppress two legs of the same rank, two odd or two even, but one on one side and the other on the opposite, so as to reduce the number of their legs to six, as in the insects, they immediately begin to walk like the latter. Finally, if you remove two more legs, they walk like quadrupeds. There is, then, as may be seen, a general law of walking among living beings that assures stability during the motion.

It is still less its physical ugliness than its singular habits that should inspire us with aversion for the spider. Contrary to the general rule, the spider in most cases lives alone. While the maternal instinct of animals is often cited as worthy of remark, we rarely

Fig. 2.—SEGESTRIA AND ITS NEST.

Fig. 3.—LYCOSA AND ITS BURROW.

grouping of the eyes so clearly characterizes the species that it has been used as a means of classification. The habits have afterward permitted of accounting for some peculiarities that we remark in the eyes.

Touch seems to be, above all, their most developed and acute sense, for, as regards hearing, we cannot concede, up to the present at least, that they have any, since we do not find that they have any ears; and it is permissible to arrange among fables the alleged musical sense that Pelisson alone (quite a poor observer, by the way) has attributed to them. When a spider comes from its retreat at the sound of an instrument, it is doubtless on account of the vibrations caused in its web by the sonorous vibrations, which, far from charming the animal, render it restless. In some species of the

hear the family of the spider and her tenderness for her young spoken of. The observer is sometimes witness of a surprising fact, of a true anomaly, at the moment of the union of these creatures. He sees a male, generally smaller than the female, and sometimes of a remarkably disproportionate size, make his appearance upon the web of the lady spider. This little creature measures his steps, advances tiptoe, with precaution, and seems to feel a hope not unmixed with anxiety. Is he afraid of displeasing her? Not at all. The courtship does not take long, and, as soon as it is finished, it is well for the husband to get away as quickly as possible if he does not wish his wife to eat him as she would a vulgar fly. This habit is not general, and we would fain believe that when the male is thus devour-

Fig. 4.—TRAP DOOR SPIDER AND ITS TUBE.

Fig. 5.—WATER SPIDERS AND THEIR BELLS.

* Continued from Supplement, No. 778, p. 12409.

ed, the wife has been fasting for a long time. This would be an extenuating circumstance.

Although the spider observes her conjugal duties so slightly, she nevertheless takes good care of her eggs, which are round and smooth. These she incloses either in a shell or silken bag according to the species. Some collect them in a bunch under their body. At the end of a fortnight the little spiders emerge from the egg. They differ but little from their parents, and do not have to undergo any metamorphosis. The mother defends them with much tenderness and devotion until they are capable of looking out for themselves. Then she drives them away and goes back home by herself. As an example, we give the *Segestria* and its tubular nest, the entrance to which is shown in Fig. 2. The various threads end at a point of the tube upon which she places her two forelegs when she is within. Aerial spiders are quite familiar to us, but we have less opportunity to observe those that live underground or in the water. The *Lycosa* has a genuine burrow (Fig. 3). The tarantula belongs to this genus.

Among other terrestrial spiders, we may mention the trap door spider, whose legs are formed, some of them for digging and others for spinning. This spider forms a circular tube varying in depth from a few centimeters to five decimeters, and of a diameter proportionate to the size of the animal. The sides are first consolidated and made even and then covered with a thickish, strongly adherent stratum of white and shining silk. The opening is closed by an earthen door covered beneath with silk. A hinge of strong and elastic silk permits the animal to raise the cover (Fig. 4). The top of the door is strewed with small stones which prevent it from being distinguished from the surrounding earth when it is lowered. It is truncated at the part where the hinge is located. Finally, upon the edge opposite the hinge are numerous small apertures into which the animal inserts its claws and braces itself against the walls in order to keep the cover hermetically closed when it is at home and an enemy tries to enter its dwelling. Certain species make curved pits with two openings; others make pits bifurcated in the interior, and vary the form and dimensions of the various parts. They fix covers at the points of bifurcations, and thus have an apartment composed of several independent parts. Finally, other species construct irregular tunnels. There is an African species that lines its burrow with a tube of white silk that is prolonged from ten to fifteen centimeters above ground, widens slightly, and is held vertically by herbs. Others of the same country prolong their burrow above ground to a height variable according to the species, and which at times reaches ten centimeters, with or without cover. This external tube, which is formed of a very strong fabric, is covered with dead leaves and earth.

In conclusion, one word upon the water spider. Gray or brown, and velvety, we see it dive, swim in the water, rise to the surface, and then dive again after it has constructed its nest. Just observe it! Here it is near the surface, head downward, allowing only the extremity of its abdomen to touch the surface. Then it quickly crosses the neighboring legs above its body. All around the part flush with the surface there forms a slight depression, and the air contained therein is imprisoned by the hairs. It is enveloped by it, so to speak, and this gives it brilliant and silvery reflections when it is immersed in the water. Then it dives, and, with its legs, collects the air that covers it into a single bubble which it deposits under a few tenuous threads, or which it fixes to blades of grass. This done, it rises to the surface, begins the same operation again, and, at every new plunge, increases its supply of air. The bubble is then visible. When the latter is of the size of a small marble, the spider throws threads over it, which, from their silvery luster, have given the animal the name of *Argyroneta*, the "silver spinner." It passes and repasses, intercrossing its threads, and fixing them by their extremities to the neighboring plants.

The bell, which is oval in form, is thus held in suspension in the water. It is about ten times larger than the animal. It is generally represented as transparent, but this is because it is not then finished. When it is finished it is opaque, like the cocoon of a silkworm. It is in this aerial place of shelter, a sort of diving bell, that our spider incloses itself, watching for the passage of the small aquatic animals upon which it feeds and which it afterward devours therein. Fig. 5 gives the aspect of these water spiders. The first one, on the surface, is in the attitude of walking; the second is in the act of swimming; the third is at rest under the air bubble. The last, to the right, has partially entered the bell through the aperture underneath. Near the surface, we observe a bell in a cluster of plants.

If the air happens to escape by accident, the spider patiently and tirelessly begins again. It does the same when the air becomes vitiated by its respiration and has to be renewed. It lays its eggs in the bell and incloses them in a silken shell that it fixes to the enveloping threads.

It was an Oratorian, the father of Lignac, who was the first to describe the habits of the Argyroneta, in 1744. He observed it in the little river Huisne, near Mans. It has since been seen in other watercourses that are usually not very swift, and especially in standing water. It is found at Versailles and Gentilly. Mr. Plateau, of Gand, found it in the drains of that city, and sent specimens to Mr. Blanchard, of the Institute, who, in turn, made observations upon them in his laboratory and confirmed the accuracy of the observations made by Lignac's father. Subsequently, Mr. Ponjade has made some new and interesting observations which have confirmed the older ones.—*F. Hement, in La Nature.*

A FALLEN LEAF.

WE have here (Figs. 1 to 4) three leaves. One is bright, fresh, and green: there is life still in it. We have just picked it from a poplar. The second, which is dry and yellow, was picked up at the foot of the tree, whence it had just fallen after its death. The third is one that we may easily find in some corner on a pile of leaves swept up by the gardener. It is a leaf of the same tree, but there is nothing left of it but the framework. Although once green and living, it now has the aspect of a skeleton, and its lines alone recall its primitive form.

The green, oblong, more or less rounded leaf, pointed at its extremity, vaguely recalls the form of a triangle. The petiole is continued by a midrim, whence branch secondary veins that are connected by a network of rimlets. The entire leaf is covered with a pellicle that can be removed in small fragments. This is the epidermis; and we observe that the lower surface is of a

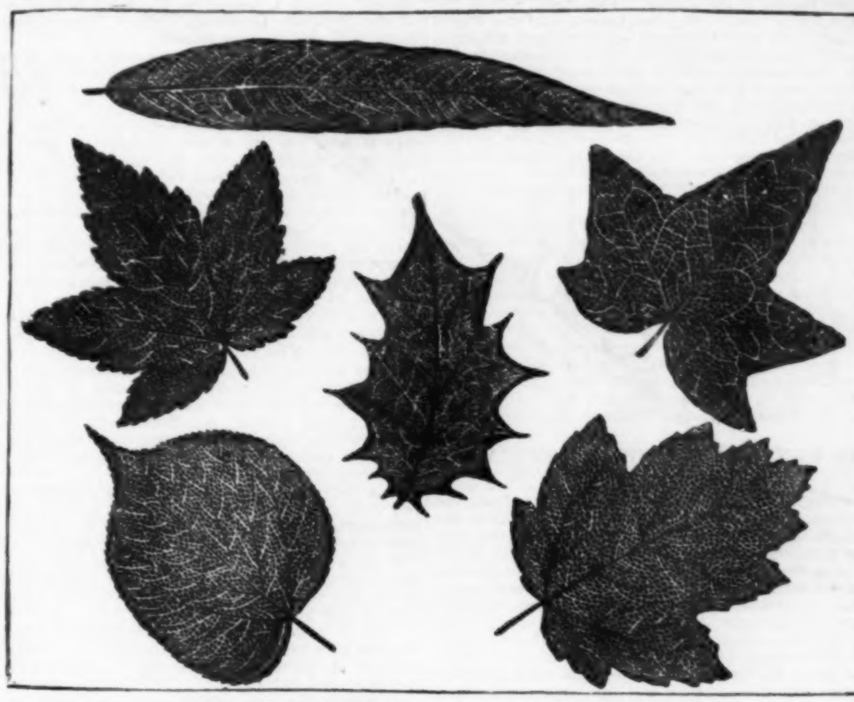


FIG. 1.—SKELETONS OF VARIOUS LEAVES.

lighter color and less brilliant than the upper surface, which faces the sky.

We have now seen all that we can discover by the naked eye, but the microscope is to reveal other details to us. Let us, by means of a pin, detach a fragment of the epidermis of the leaf and place it upon a glass slide under a microscope. We shall then see (Fig. 6) that

FIG. 2.—FRESH POPLAR LEAF.

the entire surface is dotted with small oval apertures. These are the pores or stomata of the epidermis of the leaf. These stomata are found in greater abundance upon the lower than upon the upper surface. They serve as openings to small chambers, generally in communication with aeriferous channels arranged in the green substance of the leaf (Fig. 7). The number of

FIG. 3.—DRIED LEAF.

stomata found in a leaf varies from a dozen or two to 160 000 to the square inch.

In order to examine the substance of the leaf, it is only necessary to make a very thin section of it, when an arrangement like that shown in Fig. 7 will be seen under the microscope. Between the two layers of epidermis we perceive rounded cells containing a green substance called chlorophyl, which gives leaves their color. The epidermis is composed of analogous cells, flattened and arranged alongside of one another, like the bricks in a wall, but without any trace of chlorophyl. Ramifying among these cells, and supporting them after the manner of a framework, we find the network formed by the subdivisions of the petiole. So much for the anatomy of the leaf.

If, during this examination, we place a green poplar leaf under an inverted tumbler full of water and exposed to the rays of the sun, we shall soon see bubbles of gas rising from the leaf. A disengagement of gas will also take place in darkness, but the two gases differ. In the daylight we obtain oxygen, but in darkness we obtain carbonic acid. In fact, in the light, the chloro-

FIG. 4.—SKELETON OF A LEAF.

phyl of plants decomposes carbonic acid, absorbs carbon, and sets oxygen free. In darkness, on the contrary, there is an absorption of oxygen and disengagement of carbonic acid.

Let us now examine our second leaf, the one which, yellow and dry, has fallen of itself. Why is it yellow? Chemists tell us that this color is due to a transformation that the chlorophyl has undergone. The same is the case with the red or brown leaves that strew the earth. These fallen leaves are naturally dry, since they have ceased to receive the sap that circulated in the tree,

FIG. 5.—FALL OF THE LEAF.

and all the water that they contained in their cells has evaporated, and these cells themselves have dried up.

Let us examine the extremity of the petiole of our fallen leaf (Fig. 5). It is not in the least bit ragged, but is very cleanly cut, and the vessels that passed from the plant into the petiole are not open, but are closed. It is easy to prove this by examining the surface with

a lens. It is the same upon the branch at the place where the leaf was attached. Upon the scar, we observe a series of dots, which represent the extremity of broken vessels.

But you will say to me the leaves of evergreens do not fall. In reality, the leaves of the last season remain attached to the branches until the development of the new leaves in the spring. The result is that the tree is always covered with green leaves, and this would make one believe that the same leaves remain attached to the tree from one season to another. In some species, however, the leaves persist for periods of two, ten, and even twelve years; but they fall at last, as may be easily seen by examining the soil of a forest.

How is this fall accomplished? As soon as the leaf

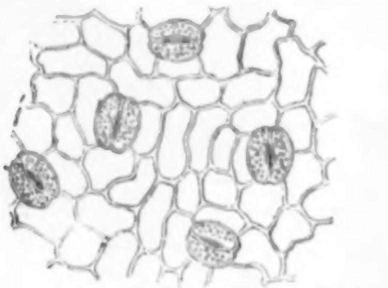


FIG. 6.—EPIDERMIS WITH STOMATA.

has developed, the process that is to detach it from the plant begins. The petiole becomes constricted at the point where it is attached to the branch, and the constriction sensibly increases until the joint that holds the leaf is so weak that the slightest torsion, or its own weight even, suffices to detach it. The leaves of some trees (those of the oak, for example), although they die and dry up in autumn, frequently remain attached to the tree until the following spring, when the development of the branch detaches them. It is clear, then, that the death and the fall of a leaf are very different things, and that the second is not the cause of the first.

Finally, let us rapidly examine the skeleton of the leaf. The vessels that carry the nutritive juices to the leaves are arranged in all the veins. It is a curious fact that the veins have, with respect to the midrim, an ar-

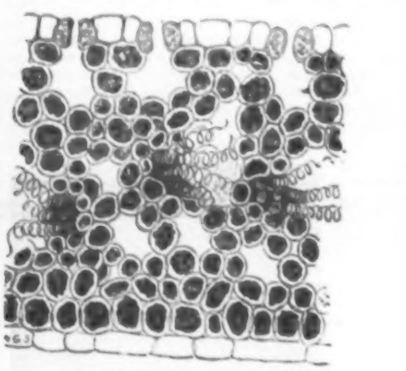


FIG. 7.—SECTION OF A LEAF.

rangement analogous to that of the branches with respect to the trunk. The leaves with a petiole indicate that the trunk of the tree that bears them begins with a straight stock. The figures that we give, and in which each leaf is easily recognized, will show the reader the relations that we have indicated much better than a long explanation.—*L. Beauval.*

[SCIENCE.]

CHANGES IN COLOR OF HAIR AND FEATHERS.

THE question of change of color of the hair is an interesting one, both from a physiological point of view and from the practical one of pathology. The physiological aspect embraces the question of how a change of color takes place—whether in existing hairs, or produced by shedding of the hair and a new growth taking its place of a different color.

It has been doubted by good authority (Hebra and Kaposi) if the hair, after being once developed, can change except by a very gradual process. This doubt is based upon the theory that the hair has no vascular or nerve connection with the general system, and must therefore be independent of nervous or systemic influence. This position is, however, not tenable. The clinical evidence is positive that the hair does change color under systemic influences, sometimes gradually, and sometimes suddenly. We hear frequently of the hair turning white in a night from violent emotions, as fright, great grief, or great joy; and it has come to be a method of expressing extreme emotion to say, "It was enough to turn one's hair white." I say it is not an uncommon thing to see mention of such cases in popular literature, but well authenticated cases are not so often found. It is recorded in history that the hair of Marie Antoinette and Mary Queen of Scots became white suddenly from the horrors to which they were subjected. Poets have not failed to avail themselves of the idea. Byron, in the "Prisoner of Chillon," says:

"My hair is gray, but not with years;
Nor grew it white
In a single night,
As men's have grown from sudden fears."

A short time since, in conversation with an eminent microscopist and pathologist,* I asked how he would explain from the basis of minute anatomy the sudden change in color of the hair. He replied that he did not explain it; that he did not believe it happened; that the reported cases were not authenticated. He further said that, from the structure of the hair and its relation to the skin, he considered it impossible.

* Dr. Gray, of the Army Medical Museum.

Duhring (third edition) is authority for the statement that Hebra and Kaposi discredit sudden canities. There is nevertheless no doubt of the fact that such change does sometimes occur; and to set the matter definitely at rest, I looked up the subject in the Library of the Surgeon General's Office. The following are some of the references found:

Dr. William P. Dewees* reports a case of puerperal convulsions under his care. From 10 A. M. to 4 P. M. fifty ounces of blood were taken. Between the time of Dr. Dewee's visits, not more than an hour, the hair interior to the coronal suture turned white. The next day it was less light, and in four or five days was nearly its natural color. He also mentions two cases of sudden blanching from fright.

Dr. Robert Fowler† reports the case of a girl sixteen years of age, apparently in good health, hair black, who found one morning in combing her hair that a strip the whole length of the back hair was white, starting from a surface about two inches square around the occipital protuberance. Two weeks later she had patches of *Ephelis* over the whole body.

In the *Canada Journal of American Science*, 1882, p. 113, is reported a case of sudden canities due to business worry. The microscope showed a great many air vesicles both in the medullary substance and between the medullary and cortical substance.

Dr. Graves‡ says most authors are of the opinion that the hair, once formed, is independent of the organism, with which opinion he disagrees, instancing *Plica polonica* as opposed to such a theory. He gives the following cases:

1. A British officer in India, forty-eight years old, fell into bad health, and became prematurely gray. He returned to England, regained his health, and in four years his hair returned to its orignal brown.

2. In a man sixty-seven years of age, hair white, chest covered with long white hair, the chest was blistered, and when hair grew out over the blistered surface, it was black.

3. In a man aged thirty-five, bald, a small blister the size of a crown piece was applied to vertex for congestion of the brain. Growth of hair followed over the blistered surface.

4. A lady, hair of vertex gray and very scanty, applied tar water. Hair grew, and was of natural color.

5. The same occurred in another case after application of citrine ointment.

In the Boston *Medical and Surgical Journal*, 1851, is reported a case of a man thirty years old whose hair was scared white in a day by a grizzly bear. He was sick in a mining camp, was left alone, and fell asleep. On waking, he found a grizzly bear standing over him.

A second case is that of a man of twenty-three years who was gambling in California. He placed his entire savings of eleven hundred dollars on the turn of a card. He was under tremendous nervous excitement while the cards were being dealt. He won. The next day his hair was perfectly white.

In the same article is the statement that the jet black hair of the Pacific Islanders does not turn gray gradually, but when it does turn, it is sudden, usually the result of fright or sudden emotions.

The following cases are of change of color from white to black:

Dr. Bruley,§ physician to the Fontainebleau, reported to the Societe Medicale, Paris, in 1798, the case of a woman sixty years old, whose hair, naturally white and transparent as glass, became jet black four days before her death (phthisis). On examination after death, the bulbs of the black hairs were of immense size and engorged with dark pigment. The roots of white hairs that remained were dried up, and two-thirds smaller in size.‖

Dr. Alanson Abbe‖ mentions the case of Dr. Capen, who had become gray, but, on recovery from disease, his hair became quite dark.

In the St. Louis *Medical and Surgical Journal*, 1845, p. 310, there is reported the case of an old man eighty-one years of age, robust and hale. His hair, from being perfectly white, became black, and the same of the beard. This man also presented the phenomena of second sight. He could read readily without glasses. The text books on skin diseases also mention cases. Several cases of sudden canities are referred to in Ziemssen.

Brown-Sequard, in his own person, noticed one day a white hair in his beard where there was none the day previous. He pulled it out, and the next day others appeared. This was observed repeatedly, and there was no doubt the hair in its entire length turned white in one night. Under the microscope these white hairs showed small air bubbles in place of the normal pigment. In a case of hemiplegia the hair became white on the paralyzed side. The same has been reported in cases of neuralgia. Other anomalous cases have been noted where the hair became white in patches, and where individual hairs have been seen alternately white and black at different stages of its growth, to which condition Karsh and Landois have given the name of "ringed hair," and ascribed it to an intermittent trophic disease affecting the hair follicle. Wilson¶ mentions a case where the hair was gray in winter, and regained its normal color in summer.

Alibert¶ and Beizel relate cases of women with blond hair which all came out after severe fever, and when new hair grew it was black. Alibert also relates the case of a young man who lost brown hair during illness, and that which replaced it was red. In the case of an epileptic girl of idiotic type, with alternating phases of stupidity and excitement, during the stage of stupidity the hair was blond, during excitement it was red. The change of color took place in two or three days, the change always beginning at the ends of the hairs. Pale hairs showed an increased number of air spaces. It has been frequently observed that, when the hair changes color gradually, the change begins in the end, and extends toward the bulb. In conversation with an eminent ornithologist on the change

* Philadelphia Medical Museum, 1807, vol. iii., p. 219.
† London Lancet, 1853, p. 556.
‡ Dublin Quarterly Journal of Medical Science, 1847.
§ Boston Medical and Surgical Journal, 1852, p. 406.
‖ Wilson, Skin Diseases, p. 877.
¶ Drocker, Diseases of the Skin, 1886.

of color in the plumage of birds, he said, "I have lately been watching hairs in my mustache turn gray, and they always begin at the ends, and it extends to the roots."

Speaking on the subject with a lady, she mentioned the case of the physician who attended her at the seashore last summer. The doctor's hair was long and quite gray. One day he came in to see her after having his hair cut, and she was surprised to notice that the gray hair had given place to black. Examination showed that his hair toward the ends had been white, and that nearer the skin black. The white portion had been removed by the cutting.

The cases here collected are only a few in comparison to what might be found; but they are sufficient to prove beyond all reasonable doubt that the hair does suddenly change color under certain circumstances, and the change takes place in existing hairs.

Analogous to changes in the color of the hair in man are the changes which occur in the lower animals. In animals and birds such changes are often periodical, as in their summer and winter coats. This occurs to a very marked degree in a great many species. Thus the ermine in summer is dark brown, in winter is pure white. Among birds the ptarmigan is white in winter and brown in summer. So with our familiar bobolink, yellow in fall, in spring black and buff. As to the question whether, in birds and animals, this change takes place in individual feathers and hairs, or whether all the old plumage and fur is shed by moulting, recent investigations favor the view that it is due to both. Dr. Elliott Coues* says it may be either or both. Mr. Robert Ridgway (Smithsonian Institution) inclines to the opinion that in birds it is accomplished by moulting. Dr. Louis Stejneger (Smithsonian Institution) was formerly of the same opinion, but recent studies have inclined him to the belief that there is also a change in the color of existing feathers. He was led to this change of belief by a critical study of the changes in color of the black and white flycatcher of Europe, and especially from an examination of a series of twenty-seven specimens of the narcissus flycatcher (*Xanthophygalia narcissina*) of Japan. His studies in full will appear in the "Proceedings of the United States National Museum, 1889." Dr. C. Hart Merriam, ornithologist of the Agricultural Department, in a letter dated June 12, 1889, says, "The change from fall to spring plumage in birds is due to moult—without exception, as far as I am aware. In the case of mammals the matter is now in dispute. Probably in the majority of cases it is due in part to moult and in part to actual change in the color of existing hairs. . . . The change in the color from immaturity to maturity is always due to the growth of new hairs or feathers."

That the change in birds and mammals is due in part, at least, to change of existing coats seems established. Sometimes this change is almost sudden, as where the change of season is very abrupt. In such case, of course, there would not be time for the growth of new hair or plumage.

In the golden plover (*Charadrius dominicus*) the black belly of summer changes to white in winter. While this change is taking place, individual feathers, part black and part white, may be seen. In Bonaparte's gull, a common gull of our coast (*Larus Philadelphia*), the black of the head of summer changes to white in winter, principally by change in color in existing feathers.

Another interesting feature of this question, as bearing on the change in the color of the hair by drugs, is the influence of certain substances administered as food in changing the color of tissues in some of the lower orders. In orange canaries it has come to be an established fact that, by feeding the parent bird with a certain kind of food, the active ingredient of which is cayenne pepper, the offspring will be of an orange color; and orange colored canaries may be seen in the stores of most bird fanciers. A food for producing orange canaries is extensively advertised by a bird dealer in Baltimore (Bishop). It is reported that the Indians of the Amazon cause green parrots to change to yellow and red by feeding them upon the fat of a certain fish allied to the shad.† Dr. Merriam, in the letter previously quoted, says: "It is well known that food affects the color in birds. Red purple finches and pine grossbeaks invariably turn yellow when caged. This is due undoubtedly to the absence of some important food element. In some of the zoological gardens of Europe it is the custom to send white spoonbills and flamingoes to Amsterdam Garden to be recolored. The particular food by which Mr. Westermann accomplishes this end is a secret, but it is believed to be a kind of shrimp or small crustacean which has a quantity of red pigment in its shell."

In the same direction are the changes of color in other tissues by particular foods. It has long been known that when pigs are fed on madder, their bones become red. This fact has been taken advantage of by physiologists in studying the structure and development of bone. The phosphate of lime acts on the coloring matter of madder as a mordant. When given intermittently to a growing animal, the bone presents alternate rings of red and white.‡

Darwin§ mentions that pigs in Virginia eat the paint root (*Lachnanthes tinctoria*), and their bones are colored pink, and it caused the hoofs of all but the black varieties to drop off. "From facts collected by Heusinger it appears that white sheep and pigs are injured by certain plants, while dark-colored individuals escaped. . . . On asking some farmers in Virginia how it was that all their pigs were black, he was informed that the black members of a litter were selected for raising, as they only had a chance of living."

Fleurens (1824) made use of madder for coloring the semicircular canals of pigeons, to outline the canals more distinctly (see also Ferrier on "Functions of the Brain," and the writings of Vulpin, the French physiologist). Mr. Lucas, osteologist of the National Museum, informs me that the bones of the crow are made purple by feeding on pokeberries. Ridgway says the bones of the Western fox squirrel are red, while those of its Eastern brother are white. No cause has been assigned for the difference. See experiments by Marci Paolini in 1841 ("Specimen quorundam experimento-

* Fur-bearing Animals.
† Wallace's Amazon.
‡ Todd's "Cyclopædia of Anatomy and Physiology," vol. iii., p. 852.
§ "Origin of Species," p. 9.

rum de vi Rubiæ ad ossa ovorumque Gallinarium patamina calcariæ coloranda," No. 1 of "Miscellanii Medichi," pamphlet vol. 1149). He gives a very good plate of the colored skeleton of a fowl, and also of its colored egg after four months feeding *Rubia tinctorium.* He also gives references to other authorities, the most satisfactory of which is Belchior ("Philosophical Transactions," vol. ix., 1732–44), who gives an account of feeding hogs and fowls with madder root and wheat meal. A rooster so fed died in sixteen days, and showed the condition admirably. Other writers take up the subject after him in the same publication.

It is reported that among workers in cobalt and indigo the hair becomes blue, also, in artisans working with copper, the hair takes a greenish hue.

The color of butterflies can be changed according to the food upon which the caterpillars are fed. More remarkable still, perhaps, is the change of color in the chameleon and in many insects, according to the color of the substance with which they are in contact.

The environment undoubtedly has a powerful influence upon the coloring of animals and birds. This is clearly illustrated in every museum of natural history. Specimens from arid desert regions are uniformly of a dull appearance, compared with those from regions of luxuriant foliage.

M. G. Pouchet,* in his work "Mechanism of Change of Color in Fishes and Crustaceans," says that change of color in fishes is due to the size of contractile colored cells placed in the skin. These are under the influence of the nerves. The author found that the particular nerves controlling them (in the turbot) were nerves of the sympathetic system. By cutting the nerve supplying a particular area of the skin, he had been able to retain that area unchanged in color, while the rest changed as the fish found itself on a dark or light surface. That the eye is the means by which this change in its condition is communicated to the fish or crustacean, and that then reflex action takes place through the sympathetic nerves on the color cells of the chromatophors, is proved by the fact that, when the animal experimented on is blinded, no further change of color occurs when it is removed from light to dark or the opposite (see also *Monthly Microscopical Journal*, 1871, vol. vi., M. G. Pouchet on "Study of Connection of Nerves and Chromoblasts," principally in fishes and batrachians).

The reasons assigned by naturalists for periodical change in color of plumage or fur are twofold: (1) sexual selection; (2) as a protection against enemies.

1. Sexual selection. The male takes on a brighter and more attractive appearance to facilitate the business of courtship and the securing of a mate.

2. As a protection against enemies. In Arctic regions birds and mammals are usually white in winter, the color of the snow; so that they are with more difficulty found by their enemies. Darwin supposes that originally only a few individuals took on this change, and, these being better protected, gradually, by a process of natural selection, only the white variety was left.

It is apparent, from what has been said, that there is very much concerning the changes of color of the hair and other appendages of the skin in man and the lower animals that is not understood. In its normal condition, the color of the hair is dependent upon the hair bulb. It is here that the melanine is secreted from the coloring matter of the blood, and from this point, as the hair grows, it permeates its cells, the intensity and shades, from black to blond, depending principally upon the amount of the coloring matter. In black hair the hair bulb is larger, contains a greater amount of melanine, and the hair itself is coarser and of more vigorous growth. In those cases where the hair has turned from white to black, and minute examination has been made, this has been found true.

In the case reported by Bruley, already referred to, of a woman aged sixty, whose hair, previously white, became jet black four days before her death, the bulbs of the black hairs are described as being of immense size and engorged with dark pigment, while the roots of the white hairs that remained were dried up and two thirds smaller in size. So, on the other hand, in change from dark to white, the hair is finer in texture, less vigorous in growth, and the hair bulbs smaller.

The sudden change in canities, when due to violent emotions, can be explained in no other way than through the bulb. It is true that there is no direct vascular or nerve connection between the bulb and its hair after it emerges from the skin, but it is also undoubtedly true that there is communication by osmosis between the cells of the papilla and those of the shaft and different layers of the hair.

Wilson † ascribes the cause of sudden whitening of hair to insufficient nutritive power of the skin, and also suggests that there may generate a gaseous fluid in the hair in place of its normal constituents. He says, further, that the fluids from the blood vessels of the skin permeate the hair, and thus change in fluids may alter the color.

In all the cases of sudden change to white, where the hair has been examined, the coloring matter has disappeared, and in its place is found an accumulation of minute air globules. The same is true of gray hair of advancing age. How the air gets into the capillary structure has never been explained. Two possible explanations are offered; one is, that in the destruction of the coloring matter a gaseous substance may be developed; the other is that air may find entrance from without, through the sides or end of the hair. It is possible to suppose a condition of the bulb producing a vacuum in the hair shaft that shall cause, by suction, a drawing in of air. The view that the air finds entrance through the end of the hair is supported in the fact that the change of color begins at the extremity.

Erector pili muscle has an important influence on pathological changes which take place in the hair bulb. This minute muscle has its origin in the true skin, and passing downward, is inserted into the base of the hair bulb, so that when it contracts it lifts the hair outward, and compresses its papilla. The effect of sudden fright causes the hair to "stand on end" by contracting this muscle. Temperature has its influence with animals and birds. In cold weather (winter) the change is to white, in summer to black. Cold, we know, contracts the skin, and thus probably causes pressure on the hair bulb. That the hair is easily influenced by external causes, as well as those which come through its bulb, is fully demonstrated. The mere fact that it can be so readily dyed and bleached artificially shows that the agents used for this purpose penetrate its substance. Bleaching agents, such as chlorine, peroxide of hydrogen, and strong alkalies, act by removing the coloring matter, and not by adding any whiteness of their own.

It remains to say a few words upon the subject of changing the color of the hair by substances taken internally.

1. In the human subject the only agent, as far as I am aware, which has been charged with changing the color of the hair, when taken internally, is jaborandi.

2. Cayenne pepper food changes the color of canary birds to orange. This is a well known fact to bird fanciers. I tried in Washington to get a specimen, but was told it was not the season for them, that they came in the autumn, also that they soon relapsed to their original color unless the cayenne pepper food was kept up.

3. The change of color in parrots by the Indians of the Amazon, from green to yellow or red, is produced by feeding the fat of a certain kind of fish (Wallace's "Amazon").

4. The restoration of certain birds to their original brilliant colors at the Zoological Garden, Amsterdam, is the result of feeding a kind of shrimp or small crustacean.

5. As analogous to the above is the effect of madder in staining the bones of pigs red, and of pokeberries coloring crows' bones purple.

It might be of interest to study the influence of diet and habit upon the color of hair in different nations of men, as, for instance, why the Saxons have light hair, and the Gauls black hair. It is within the bounds of possibility, also, that discoveries may be made in the future by which the color of the hair in the human race may be modified by judicious treatment of the parents.

Some colors of hair are not popular, especially with ladies, and it is not likely that cayenne pepper will ever become popular to produce the orange hue; but if its antithesis should be discovered, and the orange changed to black or blond, then perhaps the gentle maiden with auburn hair will disappear, and the white horse be left in melancholy solitude.

In the Philadelphia *Medical Times* of July 2, 1881, I published a case entitled "Remarkable Change in the Color of the Hair from Light Blond to Black in a Patient while under Treatment by Pilocarpin.—Report of a Case of Pyelo-Nephritis with unusually Prolonged Anuria." This was a case of a lady twenty-five years of age, and the drug was used to relieve the uræmic symptoms resulting from the anuria, which latter was extreme. On Dec. 16, 1880, treatment of pilocarpin hydrochlorate hypodermically was commenced, the dose given being one centigramme (one-sixth of a grain). The effect of this was very prompt, and the sweating and salivation produced most profuse. The relief to the uræmic symptoms was complete, the patient falling into a quiet sleep as soon as the effect of the drug ceased, and sleeping all night, awakening in the morning bright and refreshed. The pilocarpin was thus used twenty-two times from Dec. 16, 1880, to Feb. 22, 1881, requiring thirty-five or forty centigrammes. As the patient became accustomed to the medicine, it was found necessary to give two centigrammes at a dose. After Feb. 22 she began to improve, and no more was required. All her life up to November, 1880, the hair was a light blond. Four specimens of the hair were sent to the editor of the Philadelphia *Medical Times*, with the report of the case, for his inspection, and were as follows: (1) November, 1879; (2) November, 1880 (on this and the preceding date the color was the same, a light blond, with tinge of yellow); (3) Jan. 12, 1881, a chestnut brown; and (4) May 1, 1881, almost a pure black. The growth of hair was also more vigorous, and individual hairs thicker. I believed at the time, and still believe, that this change of color was caused by the pilocarpin. The lady is still, at this date (March 10, 1889), under my observation. Her hair is now dark brown, having returned to that color from black. The full report of this case can be found in the Philadelphia *Medical Times* for July 2, 1881.

The following case is reported as adding another to the evidence that jaborandi will produce the effect mentioned under favorable circumstances. Mrs. L., aged seventy-two years, was suffering from Bright's disease (contracted kidneys). Her hair and eyebrows have been snow white for twenty years. She suffered greatly from itching of the skin, due to the uræmia of the kidney disease; skin harsh and dry. For this symptom fluid extract of jaborandi was prescribed, with the effect of relieving the itching. It was taken in doses of twenty or thirty drops several times a day, from October, 1886, to February, 1888. During the fall of 1887, it was noticed by the nurse that the eyebrows were growing darker, and that the hair of the head was darker in patches. These patches and the eyebrows continued to become darker, until at the time of her death they were quite black, the black tufts on the head presenting a very curious appearance among the silver white hair surrounding them.

At the time the first of these cases was reported, the facts as stated were received with considerable incredulity, the editor of one well known Western medical journal openly refusing them credit. Others preferred the charge that the lady had formerly bleached her hair, and that when this was no longer possible her hair returned to its original color. In reply to these "suggestions," I will only say that the facts are known to scores of people at her home in Washington, D. C., and are entirely beyond question.

As illustrating the ubiquity of the daily press, and the ease with which all sorts of nostrums, valueless or otherwise, may be brought into notice through the newspapers, and how easy it is to make such a matter profitable to the advertiser, I mention an incident in connection with the case just reported.

It seems that some enterprising newspaper man became cognizant of the case, and put a short notice in a New York daily paper to the effect that a drug had been discovered that would turn white hair black, and make hair grow on bald heads, giving my name as being connected with the Smithsonian Institution. This paragraph must have been extensively copied in newspapers both throughout this country and abroad. The first intimation I had of its existence was an avalanche of letters from all parts of the country wanting information, some offering money for the receipt, others inclosing money in advance; which latter, be it known, I at once returned. One from London, England, inclosed the half of a two-dollar bill, with the information that the other half would be speedily forthcoming on receipt of the formula or medicine.

These are the only cases thus far reported in which pilocarpin has been supposed to change the color of the hair.

In 1879, Dr. G. Schmitz,* of Cologne, reported two cases in which pilocarpin stimulated the growth of the hair in alopecia. One patient, aged sixty, was completely bald. Pilocarpin was injected subcutaneously for disease of the eye. After three injections, within a fortnight, the head became covered with a thick down, which grew rapidly, so that in four months no trace of the baldness was left. No mention is made of the color. In the second case the patient, aged 34, had a bald patch on top of the head, the size of a playing card. There was total restoration of the hair after two injections, in a short time.

Schuller† tells of similar results in animals in which alopecia had been produced by injections of bacteria.

Oscar Simon‡ relates the case of a woman, aged 30, who had general baldness—head, eyebrows, eyelashes. In a few weeks, after twenty injections of pilocarpin, the hair of the whole body was restored. In other cases so treated there was no effect whatever.

Landesberg,§ of Philadelphia, says that in more than a hundred cases of eye disease treated by pilocarpin, he observed no effect whatever upon the growth of the hair. The dose and mode of administration are not mentioned.

In 1882, Julius Pohlman‖ experimented on white rabbits by hypodermic injections of pilocarpin. The dose used was large—one grain three times a day. No change in color was noted in pure white rabbits. In party-colored animals, white and brown, in one a brown spot on the back of the head deepened, and spread to a remarkable degree down the back and sides of the animal to the legs. In other individuals no change was noticed. Post-mortems in these animals showed enlarged spleen and altered suprarenal capsules.

D. W. PRENTISS

* Transactions of the British Association for the Advancement of Science, 1872, p. 152.

† Lecture on Skin.

* Berliner klinische Wochenschrift, No. 4, 1879; Medical Bulletin, Philadelphia, 1882.

† Klebs's Archiv, 1879.

‡ Berliner klinische Wochenschrift, 1879.

§ Medical Bulletin, Philadelphia, 1882.

‖ Buffalo Medical and Surgical Journal, 1882, p. 441.

ANCIENT BYZANTIUM.

By J. H. BURGESS.

CONSTANTINOPLE under the reigns of Arcadius and Honorius (who divided the empire between them into East and West, A. D. 380) contained 4,388 houses, besides 14 extensive palaces or mansions; it contained 8 thermæ or large bath establishments, 2 basilicas, 2 forums, 2 senate houses, 2 theaters, 52 porticoes, 153 private baths, 20 public swimming schools, the purple column, 2 other honorary columns, and 1 colossus, a mint, a capitol, 4 harbors, a circus, together with cisterns, nymphæa and other objects necessary for a great city; 13 curators and 65 vico-magistri had the care of the whole; and there were at that time only fourteen churches.

It will be seen from the above enumeration that the City of the East bore no comparison to Imperial Rome, either in the splendor or quantity of public edifices. The Goths and Vandals spared more of Rome than the Turks have done of Constantinople, and the basilicas and museums supplied by popes have by far outshone in splendor and magnitude the mosques and hanès of a line of sultans. The hippodrome is the first object of antiquity that attracts our notice, and upon its now disfigured arena "we are met by the shades of Justinian and Belisarius." The Turks call it by a name which denotes its original purpose, "atmeidan," or the place of horses. Septimus Severus first made a circus in the midst of the ancient Byzantium, modeled, no doubt, after the Circus Maximus at Rome, and this afterward became the hippodrome; the space which was the arena is yet clear of buildings. Three monuments of antiquity remain in their original positions: 1. A half ruined pyramid of stone, which it appears from an inscription was covered with bronze by Constantine Porphyrogenitus; 2. the twisted column of the bronze serpents; and 3. an Egyptian obelisk.

All these stand in a line, and I have little doubt they formed some of the ornaments of the spina; there is a bass-relief on the obelisk, which I take to be a representation of the spina: from the stone pyramid to the twisted column I measured forty-seven paces, to the obelisk twenty-two; the whole length of the hippodrome I calculated at 1,000 feet, that is, about half the length of the Circus Maximus at Rome. I need not stay to describe the pyramid of stones; it is a rude work and merits little observation; but the twisted column is one of the most interesting classical monuments in existence; no one ever doubted that this curious relic was brought from the Delphic temple, and was the consecrated offering of the Greeks after the glorious defeat of Xerxes.

Gibbon dwells upon this relic with delight, and even his skeptical mind admits that it is genuine. It now stands about eleven feet above ground; three serpents' tails are twisted together into a column, their heads supported the golden tripod, which, of course, has disappeared. Mahmoud with a stroke of his battle ax broke one of the serpents, and the other two heads have gone with the golden tripod. If this relic were still at Delphi, it might be doubtful whether it should follow the destiny of the Elgin marbles; but our allies, the Turks, are little curious upon these classical subjects; they have long ago scratched Arabic characters upon the folds of this Delphic column, and in the hollow of the bronze they have amused themselves by inserting stones. Under these circumstances I would encourage the idea of enriching our national depository of antiquities with the twisted column, and I should imagine that a piece of cannon, being of equal weight with the bronze, would be considered an ample equivalent for a useless piece of antiquity. The obelisk was set up in the reign of Theodosius, as it appears from inscriptions still legible on the lower plinth of the pedestal.

It would occupy me some time if I were to attempt

to describe and translate the bass-reliefs and inscriptions, Greek and Latin, which are seen on the four faces of the obelisk; I hope the task may be performed by some of our centurions during the vacancy at Constantinople. The four steeds of brass now glowing before St. Mark's at Venice, "their gilded collars glittering in the sun," were taken from this hippodrome, and most probably stood over the Porta Pompæ, that is, the gate by which the processions entered the arena, through the middle of the "Carceres." The factious of the blues and greens, which once shook the walls of this hippodrome, have long since ceased, but the scenes of cruelty and bloodshed of which the arena was the witness inflicted such a wound on Oriental Christianity that Mohammedanism had at last an easy victory.

The Moslem has now enjoyed his triumph of a thousand years, his dusky wings have overspread the fairest regions of the East. There were several triumphal columns in Constantinople; one in honor of Theodosius stood on the seventh or most remote hill, and on each side were the statues of Arcadius and Honorius; these are no longer existing, except in the pictures of Gentile Bellini; but near to the Avret Bazar there stands a pedestal sustaining the torus of a column's base, and this was the pillar of Arcadius. Not far from the Shah Dgiami, or Mosque of the Sultan's Son, stands a column called by the Turks "Kistash," or the virgin's stone; the basement and pedestal are of marble, the shaft of granite, and it has suffered by fire. On the upper plinth we can still decipher the three words, *Quod Tatianus opus;* but the English traveler Wheeler read the whole inscription. It was erected to Titian by the Emperor Marcian, who ascended the Byzantine throne in 450. The capital is a ponderous weight of marble placed on a tall shaft, and it would require all the skill and knowledge of this institute to explain the winged figures and the monograms which appear on the capital and the pedestal; such caprices generally mark a period of decline in art and genius, not unlike some authors who, for want of originality, fill up their pages with inapt quotations and try to conceal the theft. The aqueduct of Valens is best seen near the At Bazar, or horse market. Its origin, no doubt, is Roman; but its conspicuous rows of arches are chiefly the patchwork of the sultans. The next object of antiquity worthy of notice is the burnt pillar, which has attracted the special notice of travelers. It is of porphyry, the shaft composed of several pieces, the jointures concealed by garlands.

It is now bound in several places with iron bands to keep together the calcinated pieces loosened by the fire. It is said to have been brought by Constantine from Rome, and on the top was a statue of Apollo. On the upper part is an inscription bearing the name of Manual Comnenus as the restorer. When Mahmoud II. entered Constantinople, the Greeks had a prophecy that when the invaders arrived at the burnt pillar they would be stopped by the destroying angel; but the prophecy did not come true. Pocock observes that Arius died near this column. Very near to it are the subterranean cisterns, two of them now dry, and only used for spinning silk and making ropes. In one of them I counted five divisions supported by thirty-two granite columns of perfect symmetry; the second is said to have 1,001 columns, which is just the number of stories in the Arabian Night's Entertainments, but I did not take the trouble to verify the number. There is a third cistern which still serves the original purpose; it is called Batan Serai, and Gyllius counted in it 336 columns. It best explains the nature and objects of those large works made by the Greek emperors for supplying the city with fresh water. They appear to have attracted the attention of our countrymen more than any other object of antiquity, and I can conceive a practical engineer preferring the cisterns to the burnt pillar or the twisted column. The rest of the antiquities of Constantinople must be sought for in the walls of mosques and in the gardens of the inhabitants.

CONSTITUENTS OF INSECT POWDER.

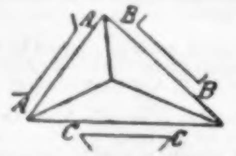
M. LACOUR EYMARD communicates to *L'Union Pharmaceutique* the results of an investigation which he has concluded on Dalmatian insect powder, the object being to ascertain why some powders of commerce differ from the proprietary powders. A portion of the powder was first submitted to the ordinary process for the distillation of essential oil, and a distillate was obtained which was opaque, owing to the presence of a very small quantity of essential oil, possessing the characteristic odor of the flowers. Some bugs and ants were put along with a portion of this odorous substance under a bell glass, but after eight hours they were as lively as ever, entirely unaffected by the volatile essence. M. Jousset de Bellerme has already shown that the essential oil of *Pyrethrum carneum* is without influence on insect life, and the same is also true of the pyrethrum of the Caucasus. We may recall the fact that Hirschsohn has recently come to the same conclusion. Continuing his work, M. Eymard extracted the resinous matter of the powder by means of ether, obtaining 5·6 per cent. of dry product, 3·8 of it being fatty matter and 1·8 resin. An alcoholic solution of the entire residue was placed on paper, the alcohol allowed to evaporate, and some insects placed on the paper. Immediately the insects showed symptoms of much agitation, and within five minutes they died. A solution of the resin alone had exactly the same effect. Alcoholic and aqueous extracts of the powder were also made, but these proved to be innocuous to insects, and M. Eymard concludes that there is no doubt that it is the ether-soluble resin which is the insect-killing constituent, and that the finer the powder is, the more active is it. The following is the result of the complete analysis of the powder:

Essential oil	A trace	
Fatty bodies, soluble in ether	3·8	per cent.
Resin, soluble in ether	1·8	"
Brown resin, soluble in alcohol	4·8	"
Vegetable albumen	1·75	"
Gummy matter	14·75	"
Inulin and starch	8·5	"
Mineral salts	7·88	"
Woody matter	56·72	"

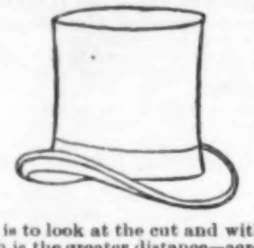
The ash—7·885 per cent.—consisted of potassium chloride, 1·94; calcium carbonate, 4·15; calcium phosphate, 0·17; silica and iron, 1·625. A mere trace of iron was only found. In a recent investigation Messrs. Schlagdenhaufeen & Reeb ascertained that the active principle of pyrethrum flowers is an acid (pyrethrotoxic acid) soluble in alcohol, amylic alcohol, ether and chloroform, which may be isolated by means of ether after having been converted into an alkaline salt and decomposed by tartaric acid in aqueous solution. Apparently this is the resin above mentioned.

VERY NEAT PUZZLES.

THE printing trade journals have bothered the printers lately by publishing two puzzles that exercise the faculty of measuring lengths with the eyes. The first has straight lines only, and the puzzle is to guess, by eye measurement only, which is the longest and which is the shortest of the three lines marked AA, BB, CC.



In the other are curves for confusing the measurer.



The puzzle is to look at the cut and without measuring say which is the greater distance—across the top of the hat, or from top to bottom. Then put your own hat on the table, about a yard in front of you, and carefully reconsider the problem. When you have made up your mind, take a foot rule and measure your hat both ways.

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TABLE OF CONTENTS.